Sky and TELESCOPE

Planetarium stars over Uruguay

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Vol. XIII, No. 9

JULY, 1954

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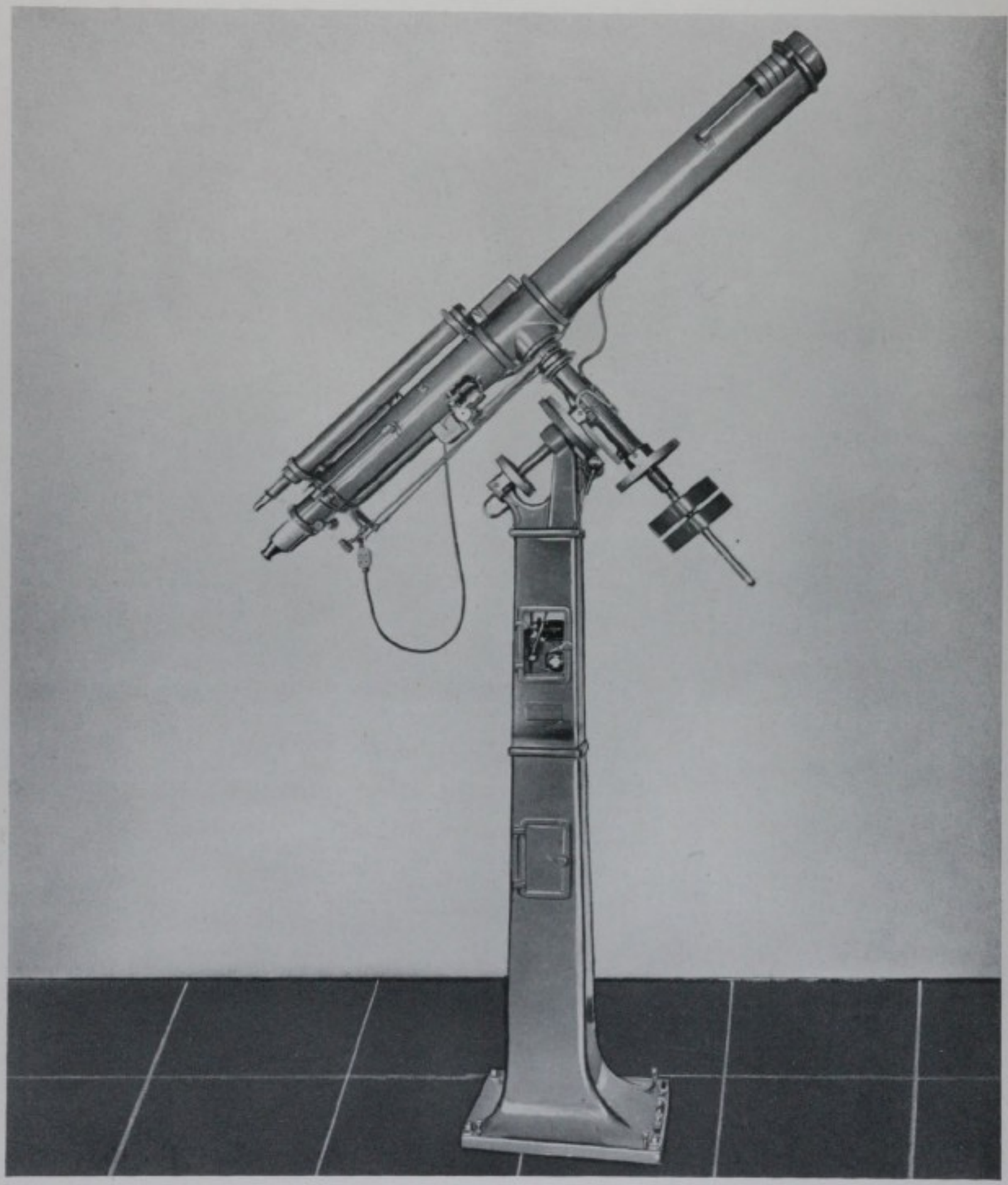

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Sky and TELESCOPE

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MORE ABOUT THE NSF AND ASTRONOMY

IN the September, 1953, issue of *Sky and Telescope* I reported on the first year of operation in astronomy of the National Science Foundation. Much has happened since then, and I should like to bring the record up to date. The funds available for research in the physical sciences have increased considerably, so that the operations of the National Science Foundation should have a very strong impact on the growth of pure science in the United States. As the budget has grown, so has the support of astronomy, in the form of funds for conferences, research grants, fellowships for pre- and post-doctoral students, and publication.

Since I last wrote, 16 new grants for research, totaling $128,000, have been made to both large and small institutions. Of the total of 24 grants since the foundation began its activity in astronomy, 11 have been to small colleges or small observatories. The geographical distribution has been extremely wide, since it is part of the intention of the foundation to foster pure research in sections where up to now only small funds have been available for it.

This $128,000 has been spread over many subjects. Astrometry has had almost as much support as studies of galactic structure; spectroscopy, theoretical astrophysics, and radio astronomy make up the balance. The average grant is for a year and a half; the sum is therefore equivalent to about two million dollars additional endowment for research in astronomy, support otherwise almost unavailable in the present state of university finances. Yet almost $150,000 for additional projects would probably have been approved had funds been available. Future expansion of the program will depend very greatly on the growth of the National Science Foundation's budget.

The NSF has taken an active interest in promoting radio astronomy research in the United States. In addition to the project at Harvard Observatory, where the 21-cm. line of hydrogen is being used to study galactic structure, the NSF supported a meeting in Washington, where 75 physicists, astronomers, radio astronomers, and electrical engineers for three days discussed important new results and future plans.

Similarly, the photoelectric conference at Flagstaff not only presented interesting new technical advances and results, but laid the groundwork for a very exciting new development. Many astronomers now believe that a national co-operative observatory can and should be established somewhere in the southwestern United States. One of its first goals would be provision of photoelectric facilities in a climate excellent for such observing. Such a co-operative institution might expand rapidly into other fields. Another conference, on astrometry, was held at Northwestern University, and led to very interesting conclusions on future programs in this country, and co-operation with European investigators.

Other meetings sponsored are of particular interest to educators in astronomy. At Swarthmore, one was held on astronomy research in small colleges (see page 306). At the University of California this summer, a teachers' conference will attempt to bring the latest information on astronomy and astrophysics to teachers of these subjects and related topics in physics, who may have been somewhat out of touch with recent developments (see *Sky and Telescope*, May, 1954, page 220). A technical symposium on stellar atmospheres is being planned at Indiana University.

An item that will interest amateur astronomers is that the NSF has given a very substantial grant to the AAVSO for the year 1954, to continue the work on the light variations of 500 variable stars, now being prepared for publication by Mrs. Margaret Mayall. This and other activities, such as the teachers' meeting and that on astronomical research in colleges, will, I believe, have great impact on the relations between professional and part-time observers and amateur astronomers.

The fellowship program has expanded, and eight outstanding graduate students in astronomy and one post-doctoral student received awards to continue their studies.

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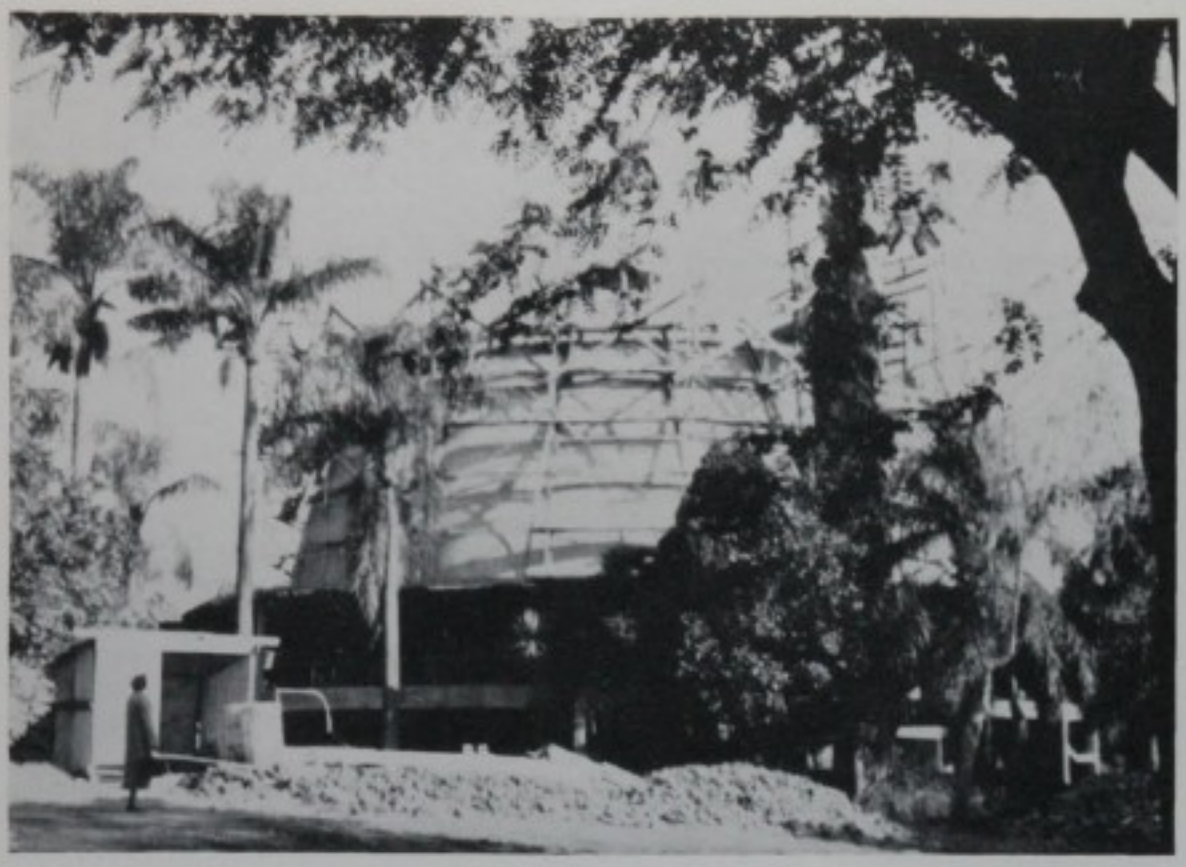
A Major Planetarium for Uruguay

By Robert R. Coles
Spitz Laboratories



This recent snapshot by Nigel O'C. Wolff shows the planetarium dome under construction, at Montevideo's Municipal Center for the Popularization of Science.

PLANETARIUMS are becoming a way of life for those interested in astronomy. It is nearly three decades since the first great planetarium projection instruments were completed in Germany, and in that time stargazers of all ages and interests have come to know the planetarium as an incomparable aid in expanding their appreciation and knowledge of the universe.

We call the planetarium projector instrument and the building that houses it by the same name. In a planetarium you can watch man-made stars on a man-made dome, you can learn constellations, you can trace the courses of the sun, moon, and planets, all with the aid of a somewhat grotesque instrument that consists, in a sense, of a hundred magic lanterns. In modern major planetarium installations, and in many of the smaller ones that operate Spitz Model A projectors, auxiliary apparatus adds colorful effects to the sky, such as the northern lights, clouds, and the rainbow; music and sound effects contribute to the awe and majesty of the presentation. Especially popular these days are planetarium demonstrations built around such themes as trips to the moon and planets, and the origin and end of the earth.

The first large planetarium projector commercially made in the United States, a Spitz Model B, was shipped to South America from Elkton, Md., in May, and is now being installed at the Centro Municipal de Divulgacion Cientifica in Montevideo, Uruguay. The building to house this instrument is nearly complete, providing a projection chamber 60 feet in diameter and seating 450 persons. The building also will contain a large Copernican orrery now on the Spitz Laboratories drawing boards, and a general astronomical museum. The whole is to be the first unit in a modern museum of science and technology.

In Montevideo, astronomical interest is growing rapidly. One of the most active scientists there is Dr. Felix Cernuschi, who some years ago was a research assistant at Harvard College Observatory, when he wrote a series in *Sky and Telescope* on the astronomical implications of the atomic bomb. He is now professor of astronomy in the University of Uruguay, and is prominent in a proposal to establish a national astronomical observatory. He has collaborated closely in the planetarium project with its chief supporter, Montevideo's mayor, German Barbato, who is himself an astronomer, interested chiefly in solar research.

Nigel O'C. Wolff, one of the original workers on the Spitz Model B program, which began in 1950, is now in Montevideo, where he will act as director of the planetarium for one year, set up the program from a public education viewpoint, give the initial lectures and train local personnel to take over after his departure. William H. Flood, Jr., who worked as production engineer at Spitz Laboratories from the first days of experimental work, is going to Uruguay this summer to install the projector in the planetarium.

The entire instrument has been designed to eliminate superfluous weight, with aluminum used wherever possible. The weight is only 1,100 pounds so that, instead of requiring the conventional support it can be suspended from structural beams behind the dome surface by four 3/16-inch steel aircraft cables. These are attached to suspension arms, on which are mounted the latitude shafts. Each cable is tested to carry more than 4,000 pounds before breaking, but the actual load is less than 500 pounds on each. This dramatic new type of support minimizes the occultation of projected images by the supporting framework and, what is perhaps more important, gives a clear view beneath the instrument to stars along the horizon for persons sitting near the center of the chamber. The front cover shows how the Spitz Model B seems to float in space.

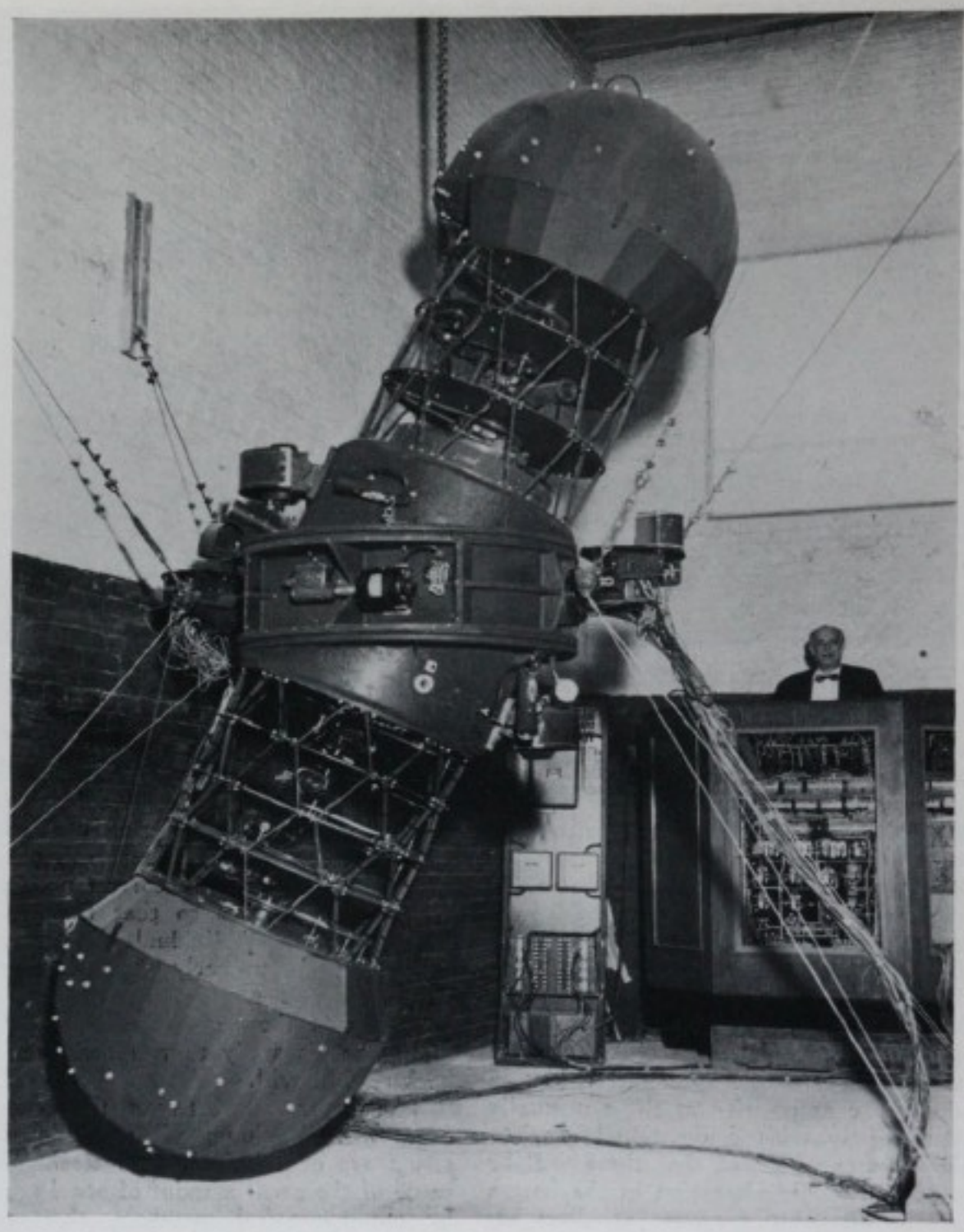
Stabilizing cables run from the suspension arms to the floor, and the electrical cables leading from the instrument to the console are attached to them. Each suspension arm includes mounting surfaces and electrical outlets for auxiliary projectors.

Mr. Wolff inspects the partially assembled solar system projectors on one end of the Spitz instrument. Note the east-west axis supports attached to the main central casting.

The over-all length is 11½ feet, with the balls containing the star projectors at either end, as in the Zeiss planetarium. The star balls are 36-inch-diameter hemispheres, from which are projected 3,083 separate star images. The faintest stars shown, of magnitude 5.8, are produced from holes 0.0135 inch in diameter. All stars of magnitude 2.0 and brighter are produced by 54 individual lens systems, so that they can be shown in their proper relative brightnesses without unduly increasing their image diameters on the dome. The brightest stars thus actually appear brighter than the faint stars without looking larger. The brightest image, that of Sirius, is a spot less than 1¼ inches in diameter on a 60-foot dome. Because of these special projectors for the brighter stars, the Spitz B sky has an intrinsically natural appearance.

The light source inside each hemisphere consists of a concentrated zirconium arc mounted in an assembly at the geometric pole of each hemisphere. This light is in turn reflected from a highly polished mirror surface of special design, permitting hemispherical distribution of light from a concentrated source. The bright-star projectors pick up this light, while the majority of the stars are projected through openings in the hemisphere by the pinhole principle. One of the chief factors in the light weight of the Spitz Model B is the elimination of the large condensing and projection lenses that fill the star balls of optical projectors.

A mechanical and optical combination automatically occults all light from each hemisphere below the horizon level. Constellation and variable star projectors are attached to fairings next to the star hemispheres. Between these hemispheres and the planet cages, on both ends of the instrument, are the clutches and gearing to turn the star hemispheres around the pole of the ecliptic to reproduce the precessional cycle of 25,800 years. In this motion, the planet cages and other central parts of the instrument do not turn.



The Uruguay projector is here suspended in the Spitz Laboratories at Elkton, Md., for a series of final tests before being dismantled for shipment to South America. The lecturer's console is at the right, with several panels removed to expose the wiring. Armand N. Spitz is operating the controls. The small cylinders protruding from the star hemispheres at each end of the instrument contain the individual lens systems that project brighter images for stars of the 1st and 2nd magnitudes. The monocular planet projectors are seen in some of the cages. General Development Corporation photograph.

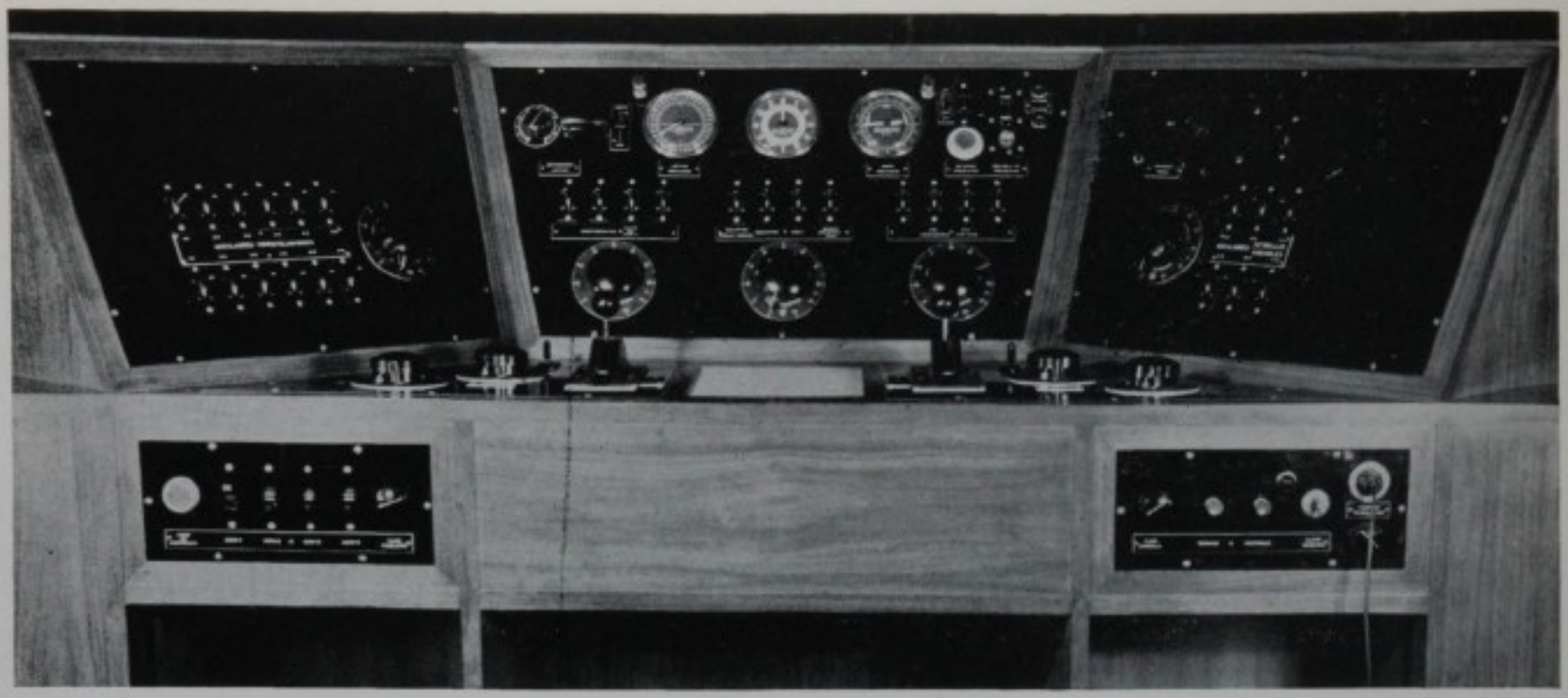
Another innovation in planetarium design is the inclusion of special devices, integral parts of the projector itself, to show the proper motions of selected star groups. In the Montevideo instrument, the proper motions in Crux, the Southern Cross, can be demonstrated for a span of 40,000 years. On projectors built for northern installations, the drifts of the bright Big Dipper stars will be shown for any time from 100,000 years in the past to that far in the future.

The instrument is mounted on an east-west axis, to provide latitude motion—the lecturer can travel north or south and completely encircle the earth in either direction at will. The central casting houses the latitude motion motor, clutch and gearing; the daily motion motor and gearing; daily motion shafts to which the ends of the instrument are attached; brush and slip-ring assemblies and electrical connections; and the initial ring gear in the mechanical train causing the daily motion of the instrument to produce annual motion of the sun, moon, and planets.

Above and below the central casting are two wedge castings which permit solar system bodies to move in the plane of the ecliptic, 23½ degrees from that of the equator. These castings carry a multitude of gearings, electrical contacts, transformers, and the like, including equator and hour-circle projectors. The northern wedge carries the indicator selsyn that controls the annual motion (year and date) indicator on the console, while the southern wedge carries the major portion of the gear train that connects the daily motion with the annual motion.

Between the central castings and the star balls are the solar system projectors. The southern cages project Mercury, Venus, Mars, and Jupiter, while the northern cages provide for Saturn, the moon, and the apparent and the mean sun, either or both of which may be projected.

The planets are driven by specially designed individual systems using toothed belts and special sheaves for reproducing the apparent motion of each planet as seen from the moving earth. This is, of course, one of the most valuable features of a large planetarium instru-



A close-up of the console shows the multitude of switches and controls. The "throttles" for daily and annual motion have ball-shaped knobs, just to the right and left of center. Labeling is in Spanish. A pistol-grip optical pointer is not shown.

ment, for the direct and retrograde motions of the planets may be demonstrated to audiences that would otherwise never observe them. With the radically new mechanical approach in the Spitz planetary motion devices, the problem of providing for inclinations and eccentricities of planetary orbits is much simplified.

The method also gives motion with the low level of noise usually obtainable with rubber belts, but the reduction ratios are as positive as those normally found only with conventional gearing. It is not anticipated that there will be any appreciable alteration in the length of the belts, but a system of idlers has been provided for almost instantaneous adjustment to erase any backlash that might conceivably come into being after years of operation.

Each December, in the early days of Zeiss planetariums in this country, at Adler in Chicago, Fels in Philadelphia, and Hayden in New York, it was customary to run back the annual motion for nearly 2,000 years to reproduce the positions of the planets as they appeared near the time of the birth of Christ. This was an amazing demonstration of the versatility of the projector but hard on the planetary gearing, for the run was made at a speed of a year in seven seconds. This meant, for instance, that the bulky moon projector whipped around in about half a second, or over 25,000 times (13 times a year, 1,300 times a century), in the trip backward in time that actually consumed about four hours of continuous operation!

Small wonder, then, that planetariums have long since adopted the practice of resetting each planet projector for its calculated position whenever some other epoch far removed from the present is to be shown. In the new Spitz projector an arrangement is provided by which, in a few minutes, all the necessary adjustments can be made. The sun is first set, in a few seconds, in its correct position for any given date, so that the earth elements of the individual planet projectors will be properly aligned. Then each planet is set for its heliocentric longitude at the desired date, and the instrument is ready to run forward or backward at will.

The separators between the planet cages are aluminum plate, while the struts are of relatively thin steel. Because of the small amount of occultation by the structural members, the sun, moon, and planet projectors are monoculars—single optical systems—instead of binoculars. These project the planets as they appear to the unaided eye, and not as they appear in a small telescope. This departure from the Zeiss tradition was made because it was felt the planets should be recognized as "wandering stars," their identities determined, in the planetarium as in the sky, by a familiarity with their changing positions and with the stars that form their background.

The moon projector reproduces all of the moon's motions with relation to the sun and stars, including the regression of its nodes. Its image shows the features normally observed by the unaided eye. The change of lunar phase is achieved by a new optical method.

The instrument console for the Montevideo installation is pictured here. Special features are noiseless switches; variable light intensities for planets, sun, moon, and auxiliary projectors; and airplane-type throttle controls. Daily and annual motion in forward or reverse may be set at any speed, varying smoothly from virtually zero to the high speeds of a day in one minute or a year in 12 seconds. The smooth acceleration of these electronic controls not only preserves the illusion of the sky in apparent motion, but relieves the instrument of mechanical strain.

An innovation at the console is an electronic "memory" precession-resetting device, so that the lecturer can touch a button and the planetarium will automatically reset itself to the current epoch without further attention.

Ample spare circuits are provided, with blank controls already built into the console. There is a panel of jump circuits to permit the lecturer to set up any desired combination or sequence of projectors. In the nearly six miles of wiring, as in the 40,000 other parts, standard equipment was used wherever possible, to facilitate future servicing and replacement of parts. Servicing is easy. To dismantle and reassemble earlier planetarium projectors requires weeks of work. If necessary, two men can take the Spitz instrument apart to reach its innermost parts in less than an hour, and it takes little longer to put it together again.

Another large American planetarium projector was built by the staff of the California Academy of Sciences and placed in operation in San Francisco in November, 1952. It was described by Leon E. Salanave, of the Morrison Planetarium, in *Sky and Telescope* for December, 1952.

The inventor of the latest large new projector, Armand N. Spitz, is also responsible for the design and manufacture of the more than 110 small instruments (the Spitz Model A) now in existence throughout the world, and for the recently marketed Spitz Junior, a miniature projector for which thousands of orders have been placed.

Spectra of Visual Double Stars--II

By Otto Struve, *Leuschner Observatory, University of California*

IN OUR DISCUSSION last month, we noted that quite frequently the brighter component of a visual binary star is somewhat more brilliant than would be expected from its spectrum or its mass. In such cases, the brighter component also appears to rotate more rapidly than the fainter star. In interpreting these effects, it is useful to consider some apparently related phenomena.

First of all, there is the remarkable tendency of the upper portions of the main sequences in galactic clusters to

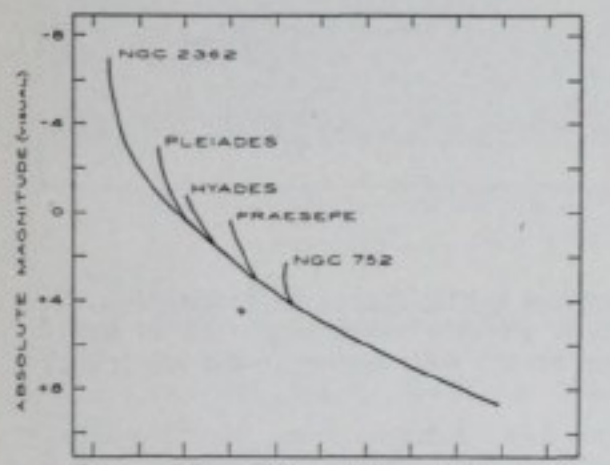


Fig. 1. The main sequences of five galactic clusters, by G. R. Miczaika, from the 1953 Liége symposium.

rise above the conventional main sequence of the Hertzsprung-Russell diagram, as shown in the illustration by G. R. Miczaika (see Fig. 1). As was first suggested by M. Schwarzschild, the slopes of the lines joining the components of double stars, as plotted in the H-R diagram, might be regarded as representing a statistical mixture of a great many galactic clusters of different ages. Among the galactic clusters themselves, however, this effect occurs only in the earlier spectral types, at the latest in type *F*, in the case of the cluster NGC 752. We have already seen that among the double stars departures can be observed as late as *G*0 and *K*0.

This difference between galactic clusters and double stars is almost certainly one of age. Galactic clusters are exceedingly vulnerable to the effect of perturbations by the Milky Way as a whole and by individual stars and gas clouds in it. Hence, all galactic clusters that we now observe are probably relatively young formations. They disappear as clusters before they reach ages of the order of three or more billion years.

On the other hand, the visual double stars are among the most stable formations in the universe. Hence they may be either young or old. Those that are relatively young must have slopes consistent with the main sequence. Those that are old undoubtedly have steeper slopes. Thus, in many respects the visual binaries tend to fit into one evolutionary sequence, between the galactic clusters on the one side and the extremely old globular clusters on the other.

Another intriguing similarity between galactic clusters and double stars pertains to the rotations of the subgiant components. One of the most remarkable results of spectroscopic investigation was the discovery, many years ago, that all but one of the brighter stars in the Pleiades have very large rotational velocities. This has never been satisfactorily explained, and it appears to be a similar problem to that of rapidly rotating bright components, such as in the visual double star ADS 8257 discussed last month.

Next, we have O. J. Eggen's remarkable result that the unusual stars among the Hyades cluster, on the right side of the steep upper branch in his H-R diagram, possess systematically larger rotational velocities than stars that are less extreme.

Further, we recall that several years ago J. L. Greenstein found that nearly all single *F*-type giants and subgiants possess large rotations. This discovery has been confirmed and extended in a recent investigation by G. Herbig and his associates at the Lick Observatory.

All this seems to indicate that for some strange reason a main-sequence star as it grows older not only departs toward the upper right side of the diagram but also increases its axial rotation. The only clearly contradictory evidence has been found by A. Slettebak among the single *A*-type stars, where the rotations tend to diminish for stars increasingly farther from the main sequence in the direction of greater luminosity. This important departure may give an important clue to the evolution of early-type stars.

Since it is tempting to regard the foregoing processes in the light of evolutionary theories, we shall start with the ideas proposed by A. R. Sandage at the Liége symposium in 1953. Assume that the material within the stars is not subject to a large amount of mixing; therefore the nuclear processes occur in the central cores without appreciably disturbing the usual chemical composition of the outer layers. Under these conditions, we are fairly certain that for stars with surface temperatures of the order of 6,000° (like the sun), the gradual burning out of the hydrogen in their cores displaces the stars approximately vertically in the H-R diagram. Since the evolution of the hotter stars proceeds more rapidly than that of the cooler stars, the main sequence will, after a lapse of about five billion years, assume the position indicated in Fig. 2.

After this process has continued until the star's core has grown to its maximum size, a new phenomenon becomes significant. This is the contraction of the burned-out core. All stars that lie to the left of the uppermost track of Fig. 2 have presumably been subject to this new process.

To describe the evolutionary tracks of these slightly hotter stars, Sandage has developed a semiempirical procedure which relates the present (observed) relative numbers of stars with different luminosities in globular clusters with the relative numbers that the stars had when they were young and therefore were located upon the original main sequence. His diagram (Fig. 3) shows these evolutionary tracks. It is suggested that the present H-R diagrams for globular clusters can be accounted for in terms of the two physical processes mentioned, provided that only those stars originally between about 6,000° and 7,000° are now located upon the nearly vertical branches of the cluster diagram.

If the original cluster contained hotter stars, they must have evolved more rapidly and disappeared from the diagram, possibly being converted by some unknown process into faint blue stars or even white dwarfs. The dot in Fig. 3, near the center, shows the location of the brighter component of Zeta Herculis, for which Sandage assumed a mass 1.12 times that of the sun. Since the nuclear processes do not appreciably diminish the mass, this star must have been slightly above the sun on the main sequence when it was young.

The slightly larger mass that we adopted last month would not materially

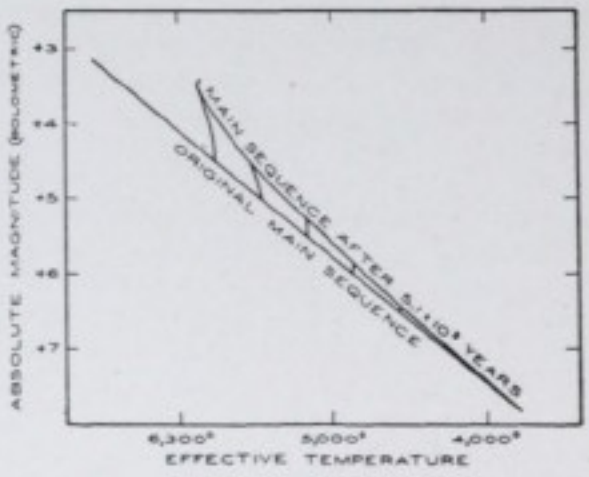
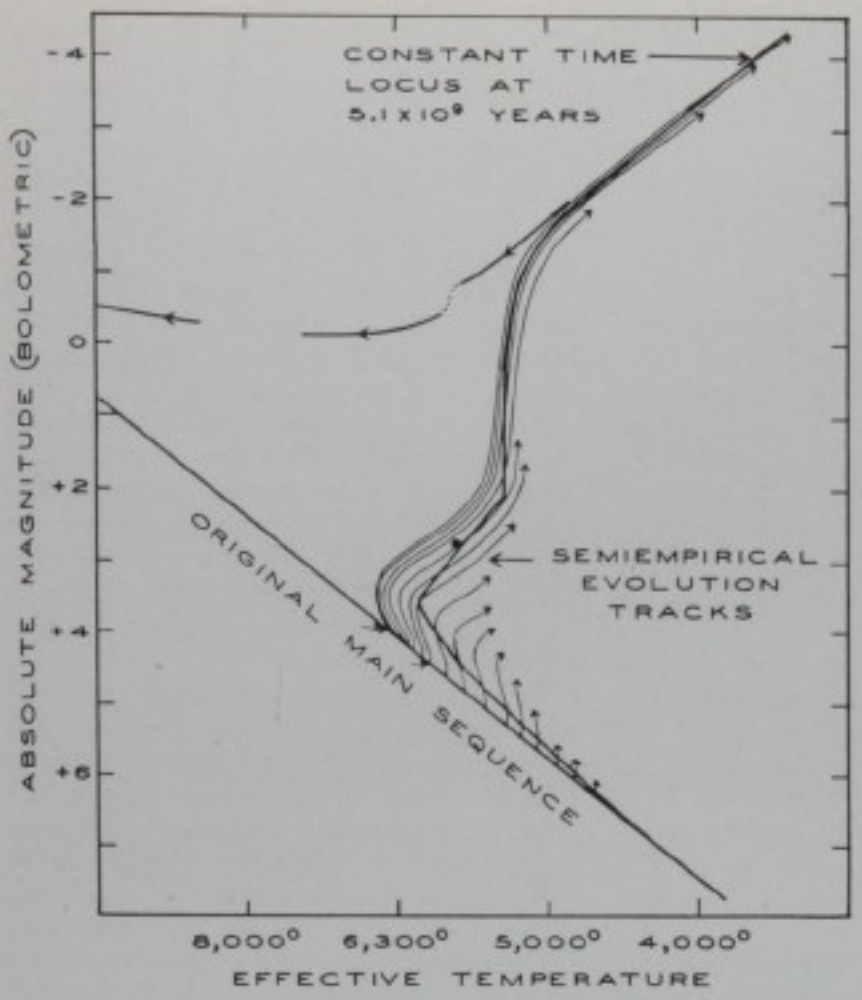


Fig. 2. Vertical lines show evolutionary changes of main-sequence stars in five billion years, from calculations by Schoenberg and Chandrasekhar.



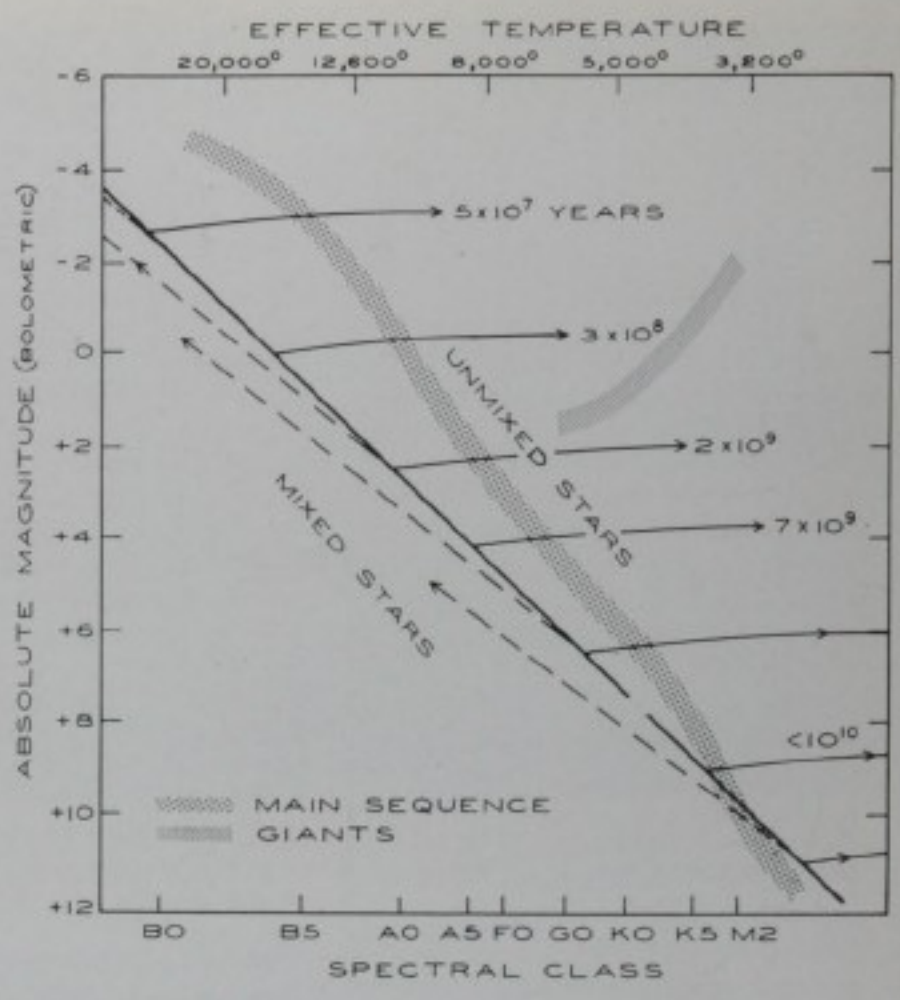


Fig. 3 (left). In this diagram by Sandage, that portion applying to absolute magnitudes fainter than +3.5 is from Fig. 2. The observed color-magnitude diagram of the globular cluster M3 brighter than absolute magnitude +3.5 is plotted and labeled "Constant Time Locus at 5.1 × 10^9 years." The gap in the horizontal branch with arrows to the left is for variable stars. From the 1953 Liége symposium.

Fig. 4 (right). The evolutionary tracks of mixed and unmixed stars, according to Roy. Adapted from the "Monthly Notices" of the Royal Astronomical Society.

alter the argument: We would still regard Zeta Herculis A as a very old star that started its life history on the main sequence below and to the left of its present position.

This particular star does not possess a large rotational velocity, but for several other subgiant members of binary systems it would be tempting to attribute their rapid rotation to that typical for stars at their place of origin on the main sequence. Thus, the brighter component of ADS 8257, which is now an *F*5 subgiant, would have been originally a star of class *A*0 or *A*5, when on the main sequence. The *A* stars often show rapid rotation, and it would, therefore, not be surprising to find that the processes displacing them toward the right in the H-R diagram preserve their original rotations.

However, this hypothesis is not consistent with the evolutionary tracks developed by Sandage, which displace a star much more along vertical lines than toward the right along horizontal lines. Of course, the theory of Sandage does not extend to stars of spectral types *F* or *A*. It is possible that the actual tracks of the hotter stars tend to be more nearly horizontal than those of the cooler stars that he had examined.

An alternative view, the evolutionary tracks proposed by A. E. Roy in the *Monthly Notices* of the Royal Astronomical Society (*112*, 484, 1952), is concerned entirely with horizontal tracks of the kind we have just mentioned for *A* stars. Figure 4 shows changes in position that take place most rapidly for the hottest stars, provided they are unmixed. For mixed stars the situation is entirely different.

Since both Roy and Sandage have had to make certain assumptions, we cannot be certain that the evolutionary tracks actually run as either of these authors has suggested. For the cooler stars the semiempirical procedure of Sandage has a great advantage. Can similar tracks also apply to the hotter stars which have presumably disappeared from the globular clusters?

Returning to the diagram for the galactic clusters, the vertical stubs of their main sequences can probably be accounted for on either theory. As yet, we do not have adequate information concerning the masses of, let us say, the brighter stars of the Pleiades. If they had originated as *O*-type or perhaps early *B*-type stars and had evolved along horizontal tracks, we would expect them to have considerably larger masses than are normally attributed to main-sequence stars of their present spectral types, which are about *B*8. If, however, their evolutionary tracks were almost vertical, then their present masses should not be greatly different from those of main-sequence *B*8 stars.

In the first case (horizontal tracks), the subgiants of galactic clusters, and, of course, also the subgiants of visual double stars, would agree quite closely with the conventional mass-luminosity relation. In the latter case (vertical tracks), these subgiants would appear too luminous for their masses.

Zeta Herculis A does seem to be slightly too luminous for its mass. This would tend to support the arguments of Sandage, at least in so far as the cooler stars are concerned. Our information concerning departures from the mass-luminosity relation among the hotter, more massive stars is inadequate to answer our question uniquely.

We should keep our minds open to the possibility that the properties of the subgiants in galactic clusters and in visual double stars are not the results of evolutionary changes. We know that some of the departures of stars from the main sequence are caused by otherwise undetected companions. If, for example, the primary component of ADS 8257 were itself a binary consisting of identical components, its integrated brightness would be about two thirds of a magnitude above the main sequence. The spectral lines of this star do not, at present, suggest that it is a close binary.

However, it does not seem impossible that rapid rotation would produce an excess of luminosity even though the star would appear optically as a single

(Continued on page 299)

This aerial view of the Talemzane crater shows its appearance from the north.

The Crater of Talemzane in Algeria

By L. F. Brady, *President, Meteoritical Society*

A STRIKING circular crater over 5,600 feet in diameter is shown on the 1:200,000 topographic map of Algeria, about 75 miles east-southeast of the Oasis of Laghouat. R. Karpoff, of Paris, had noticed the feature on the map, and he made several visits to the area in 1951 and 1952 for thorough studies of the crater and its structure. On his latest visit, in September, 1952, I had the opportunity of accompanying him to the site and spending several days there.

The crater is reached by automobile by starting on the very good blacktop road from Algiers to Laghouat. From the latter place, the blacktop continues toward Ghardaia, but 30 kilometers south of Laghouat, we turned east for 50 kilometers on a fair road, to the wells of Delaa, an extraordinary spot. From there east to the crater on only fair road it is 40 kilometers; the nearest permanent water is at Delaa.

Monsieur Karpoff found it difficult to explain the crater characteristics by such processes as large-scale solution and collapse or volcanic explosion, for vulcanism and large-scale faulting are unknown in the region. It had therefore occurred to him that the crater might be of meteoritic origin. Although no meteoritic material has yet been found, in spite of considerable search in and near the crater, an impact origin seems to be the most reasonable explanation. Thus, the crater of Talemzane at present stands second in size to Ungava crater in Canada among those suspected to be of meteoritic origin.

Evidence that the crater is due to impact and explosion includes the fact that the strata of the rim are upturned from the floor of the crater at angles from 15 to 60 degrees or more, a condition unique in the marine Cretaceous of the area, which lies almost horizontally. Further evidence is afforded by the presence in many places on the rim of blocks of ejected limestone, often of enormous size, though these are as a rule worn down to the level of the gravelly surface. The change in the direction of their stratification is very clear, however, and their presence can hardly be explained by explosion.

That the crater is of considerable antiquity is shown by the extreme maturity of the relief of the surface, the apparent depth of the fill, and the fact that in several places on or near the rim a thin stratum of reddish sandstone is found lying unconformably on the cretaceous limestone. This substance is of a type usually referred by Saharan geologists to the late Pliocene. The age of the crater may therefore be tentatively estimated as latest Pliocene or early Pleistocene.

The highest points of the rim are now some 220 feet above the floor of the crater, but the rim, whose slope

A dry stream bed cuts the northern (near) rim of the crater.

is everywhere steeper on the inner side, is deeply cut by a series of gullies draining into the bowl of the crater, which has no outlet. Aerial views suggest that the formation of the crater disturbed the original drainage pattern of the area. Now an *oued* or stream bed describes a noticeable arc around the east side of the crater and drains the area to the north and northeast, rejoining the Oued Zagrir which flows (occasionally) toward the Sahara in the neighborhood of the Oasis of Guerrara.

It is probable that before long well borings will be made in the floor of the crater of Talemzane, which may be of great value to the Arab herders of the area by developing much-needed water, and to geologists and meteoriticists by producing evidence of the crater's origin.

The writer has translated a discussion of the crater by Karpoff, and this translation is published in the first issue of the new journal, *Meteoritics,* published at the Institute of Meteoritics, University of New Mexico, Albuquerque. The reader is referred to that article for further details, including other pictures of the crater and a topographic sketch map.

Several other craters of possible meteoritic origin have been seen and photographed from the air in other parts of the Sahara. One of these, Aouelloul, in the western Sahara, has been visited several times by T. Monod and others; the discovery there of silica glass closely resembling the Darwin glass of Tasmania (a form of tektite) makes the meteoritic origin of that crater practically certain, although no remains of actual meteorites were found.

The whole of the Sahara is being more and more thoroughly explored on the surface and from the air, and it is very possible that other craters, hitherto inaccessible, will be examined and recognized as being of meteoritic origin.

This ejected boulder lies about 300 yards outside the crest of the northwest rim of the crater. The exposed surface measured 34 by 18 inches. The vertical stratification of the boulder clearly distinguishes it from the surrounding undisturbed formations.

NEWS NOTES

By Dorrit Hoffleit

A POSSIBLE OLD NOVA

Interest is growing in a remarkable star on the Cygnus-Draco boundary, already noted as a faint variable by P. P. Parenago at Moscow in 1946, and which Donald A. MacRae, while at Warner and Swasey Observatory, found in 1952 to have a spectrum exceptionally bright in the ultraviolet. The position of this star is $19^h\,05^m\,45^s$, $+43^\circ\,56'\,12''$ (1950).

Two papers in the April *Publications* of the Astronomical Society of the Pacific discuss the light variations and spectrum of MacRae $+43^\circ 1$. Merle F. Walker, Mount Wilson and Palomar Observatories, has studied it photoelectrically in three colors, with the 100-inch Mount Wilson reflector and a 20-inch reflector at Mount Palomar. Superimposed on slower variations, the star shows large fluctuations with cycles from one to 30 minutes—a very unusual case.

In blue light, Dr. Walker finds magnitudes between 12.7 and 14.0, while Parenago's earlier photographic observations ranged from 10.3 to 11.2. Allowing for a small systematic difference between the two observers, the total variation was probably 3.5 magnitudes.

The spectrum of the star was observed with the 200-inch Hale reflector by Jesse L. Greenstein, California Institute of Technology, who found resemblances to the spectra of old novae. Dr. Walker in his article suggests that MacRae $+43^\circ 1$ is a former nova, or perhaps a pre-nova that has not yet flared up.

There is some indication that, during the rapid fluctuations in brightness, the rise in light usually takes two minutes, irrespective of amplitude, but the greater the amplitude, the slower the decline in light. Dr. Walker suggests, therefore, that the star brightens as a shock wave heats its photosphere, and fades as it cools by radiation.

Analogous rapid fluctuations have been found in three of five old novae examined photoelectrically by Dr. Walker: Nova Persei 1901, T Coronae Borealis, and Nova Cygni 1876.

POULKOVO OBSERVATORY REBUILT

The Poulkovo Observatory near Leningrad, U.S.S.R., was destroyed during World War II, but much of its equipment and library had been evacuated. It has been reconstructed, and two American astronomers, Dr. Dirk Brouwer, Yale University Observatory, and Dr. J. J. Nassau, Warner and Swasey Observatory, were invited guests at the reopening ceremonies on May 20-22. Following the dedication, two international conferences were held on astrometry and variable stars, at which Drs. Brouwer and Nassau presented papers. Astronomers from Canada, France, Great Britain, the Netherlands, and Sweden also were invited to attend.

RADIO SOURCE IDENTIFICATIONS

The list of radio sources in the heavens is rapidly increasing, but most of these have defied identification with optically observed objects. Apparently this has largely been because of the low positional accuracies of the early radio observations. Now that more precise positions are being obtained, some definite identifications have been made. These are described by W. Baade and R. Minkowski in the *Astrophysical Journal* for January, 1954. Their discussions are illustrated by photographs with the 200-inch and 48-inch telescopes on Palomar Mountain.

The radio sources recognized optically form four distinct groups: remnants of supernovae (Crab nebula and Tycho's supernova), a new type of galactic emission nebulosity, peculiar galaxies, and normal galaxies. However, not all objects in any one of these categories are radio emitters, at least they do not emit radio energy to the same degree.

The strongest radio sources of the second type are Puppis A and the one in Cassiopeia, where filamentary nebulae with large internal motions and very peculiar spectra are observed. The Cassiopeia source appears to be made of broken bits of nebulosity that show only on red-sensitive plates; some are elongated streaks up to 25 seconds of arc in length, while others have almost a stellar appearance. Their spectra vary considerably; one filament shows strong forbidden oxygen lines but no hydrogen, indicating that the excitation of the nebulosity may be by collisions rather than by radiation. Puppis A shows the same characteristics as the Cassiopeia source, but on a less spectacular scale.

Among the peculiar galaxies, two varieties seem to be represented: the peculiar galaxy M87 (NGC 4486), and colliding galaxies. The former, a spheroidal system belonging to the Virgo cluster, shows on suitably exposed photographs a straight, blue jet two seconds of arc wide extending 20 seconds of arc from the nucleus of the galaxy. There are several strong condensations in the outer part of the jet, but its nature is unknown.

Three examples are cited of colliding galaxies, Cygnus A, NGC 1275, and NGC 5128 (Centaurus A). Cygnus A is the strongest radio emitter. What at first appears to be a single 18th-magnitude galaxy (seen through a galactic "window" only four degrees from the Milky Way plane) proves to be two

systems face to face, their centers appearing about two seconds of arc apart. Their nuclei show strong signs of tidal distortion. The Palomar astronomers write:

"As far as the stars of the colliding systems are concerned, such a collision is an absolutely harmless affair. The average distance between two stars is so large that the two galaxies penetrate each other without any stellar collisions. The situation is very different for the gas and dust imbedded in the two systems. Because of the much shorter free paths of the gas and dust particles, the collision of the two galaxies means a real collision of the imbedded gas and dust, which are heated up to very high temperatures, since the collisional velocities range from hundreds to thousands of kilometers per second."

The total radio energy emitted by Cygnus A is 8×10^{42} ergs per second, while the optical emission is only 5.6×10^{42}. The radio emission probably arises from the energy of collision, which would amount to 10^{59} ergs for a relative velocity of the two galaxies of 500 kilometers per second.

NGC 1275 appears to be a tightly wound spiral penetrating a loose spiral whose arms are distorted by tidal forces. This radio source emits roughly 1,000 times less energy than Cygnus A but 300 times more than our own galaxy.

The third object has long been a problem to astronomers, who could not decide whether it is galactic or extragalactic in nature. The radio evidence and new Palomar photographs indicate that it is probably a spheroidal galaxy seen behind an edgewise spiral; the arms of the latter are strongly distorted as if by tidal action of the spheroidal galaxy, indicating that here is, perhaps, another actual collision.

IN THE CURRENT JOURNALS

THE SIZE AND SHAPE OF THE EARTH, by O. H. Chilton, **Monthly Notes** of the Astronomical Society of South Africa, March 31, 1954. "When determining the terrestrial latitude and longitude of an observatory, despite the great accuracy of the instruments used, . . . the values of latitude and longitude so obtained are inescapably in terms of the direction of gravity at that particular place. They are geoidal latitudes and longitudes, and as such may be misleading. An anomalous deviation of gravity could cause a difference of as much as one mile on the Earth's surface between such geoidal positions and those computed by geodetic survey."

GRAVITATION — STILL A MYSTERY, by Paul R. Heyl, **Scientific Monthly,** May, 1954. "The more we study gravitation, the more there grows upon us the feeling that there is something peculiarly fundamental about this phenomenon to a degree that is unequaled among other natural phenomena. Its independence of the factors that affect other phenomena and its dependence only upon mass and distance suggest that its roots avoid things superficial and go down deep into the unseen, to the very essence of matter and space."

TIDES IN THE ATMOSPHERE, by Sydney Chapman, **Scientific American,** May, 1954. "Like tides in the sea, they rise and fall twice a day. Unlike sea tides, they are due to the sun more than the moon. Still the moon contributes a tiny beat to their regular oscillation."

SKY ATLAS ON SALE

Mount Wilson and Palomar Observatories will now receive orders for the National Geographic Society-Palomar Observatory Sky Atlas, according to an announcement in the *Astrophysical Journal* for March. Orders will be accepted only until October 1, 1954, and only one printing of the atlas is planned, based on the number of orders received.

In 1949, the 48-inch Schmidt telescope on Palomar Mountain began photographing the observable region of the sky (north of declination $-27°$), each 7-by-7-degree field being photographed in blue and red light in immediate succession. Both exposures reach the limit of the instrument, which is photographic magnitude 20.3. The scale of the 14-by-14-inch plates is 67.1 seconds of arc per millimeter.

Although the survey will not be completed until 1956, the first section of the atlas is scheduled for publication next year. In the fifth year of the work, better photographic materials and long periods of good weather aided the progress of the survey. Twice as many acceptable plates were obtained as in the previous best year.

The atlas will consist of negative photographic copies on double-weight paper, 14 by 14 inches, and the limiting magnitude will be retained, although the resolution will suffer slightly in the fine-grain reproduction process. Since the price will cover only production and handling of the prints, it will not be possible to set a fixed charge in advance. Estimates based on present labor rates and material costs indicate that if 50 orders are received the price may be about $2,000 per set of 1,758 prints (879 blue and 879 red exposures), but this figure may drop to $1,600 per set if 100 orders are processed.

It is planned to distribute the atlas in three or four sections, to be delivered and paid for at delivery in approximately yearly intervals. The actual price can be established only after the printing of a section is finished; and cancelations will not be accepted if the actual price exceeds the estimated price. Orders should be addressed to Mount Wilson and Palomar Observatories, 1201 E. California St., Pasadena 4, Calif.

SUPERNOVA IN NGC 5668

A supernova of apparent magnitude 14 has been found by Paul Wild on a photograph taken May 3rd with the 18-inch Schmidt camera at Mount Palomar. The exploding star burst forth in the exterior galaxy designated NGC 5668, in Virgo, and may have reached a brilliance about 100 million times that of the sun. It was a supernova of Type I, according to spectra obtained by Milton L. Humason with the 200-inch Hale telescope; this type is about six times as bright as supernovae of Type II.

Succeeding observations showed the supernova slightly dimmer; thus it is possible that it was already declining at the time of discovery, and that maximum brightness occurred earlier and was not observed.

In a photograph of this galaxy made three years ago with the 18-inch Schmidt, no stars were visible. Because of its great distance, NGC 5668 normally looks like a fuzzy blurred area. This is the first supernova discovered by the Palomar Observatory in any galaxy since March 20, 1950, when one was found in IC 4051, in Coma Berenices.

SPECTRA OF VISUAL DOUBLE STARS — II

(Continued from page 296)

object. About 20 years ago, several investigations were carried out to find whether stars with diffuse lines differed systematically in luminosity from stars with sharp lines. The results were inconclusive. Until this question has been resolved, we shall not be entirely certain that we are concerned with evolutionary changes.

Still another possibility was suggested by H. Bondi in a private conversation. Perhaps the more massive stars have recently swept up interstellar matter possessing large amounts of rotational momentum. Since it may take a long time for the excess angular momentum to become properly distributed over the entire mass of such a star, its outer layers may, temporarily, rotate very rapidly.

MORE ABOUT THE NSF AND ASTRONOMY

(Continued from page 291)

astronomy now consists of Drs. L. H. Aller, D. Brouwer, J. L. Greenstein, G. P. Kuiper, M. Schwarzschild, K. A. Strand, O. Struve, A. E. Whitford, and F. L. Whipple (who has been appointed chairman for next year). We will be very fortunate in having for the coming year Dr. Peter van de Kamp, of Swarthmore, serving in the National Science Foundation as program director for astronomy.

JESSE L. GREENSTEIN
California Institute of Technology

The Story of Cosmic Rays--VI

By W. F. G. Swann, *Director*
Bartol Research Foundation, Franklin Institute

6. The Origin of the Primary Cosmic Radiation

EARLY STUDENTS of the primary cosmic radiation pictured it as distributed with equal intensity over the whole of galactic and intergalactic space. Such an idea is attended with considerable difficulty. Thus, R. D. Richtmyer and E. Teller have pointed out that on such a view the total energy carried by all cosmic ray particles is much more than all the energy ever emitted by stars, together with their kinetic energy. In fact, it would be an energy less by only a few orders of magnitude than the total energy ($E = mc^2$) represented by all the matter in the universe.

Difficulties also arise as to how the supply of cosmic ray particles can be maintained, since it is necessary to allow for a continual loss as a result of their collisions with atoms in space.

Such considerations have led to the general concept of an extensive magnetic field confining cosmic radiation to a definite region, a galaxy for example, as mentioned last month. Such a theory removes the necessity of extending the rays to the whole of intergalactic space, and avoids the enormous amount of energy which such extension would impute to cosmic rays in the universe as a whole.

There are three general possibilities to account for the enormous energies of the rays themselves, from 10^{10} to as high as 10^{17} electron volts:

1. The particles may receive energy by relatively small forces acting over great distances.

2. They may receive energy in single acts associated with enormous forces.

3. The particles, with their energies, might be considered to have been born with the universe, their properties depending upon the circumstances associated with that event.

The third possibility, first propounded by the Canon Lemaitre, cannot very well be proven or disproven. At the time of the supposed origin of the universe, conditions may have been so drastically different from what they are now that in our ignorance we may assume almost anything to form a basis for the origin of the high energies.

The second category is deemed unlikely because we now know that the cosmic radiation contains particles much heavier than protons. Quantum theory demands that a process that could give them their energy in a single act would disintegrate them.

The first category, therefore, presents the natural field for explanation in terms of our present knowledge. This category may be divided into two classes, in one of which the energies are acquired little by little by processes that are primarily mechanical, while in the second the forces are primarily electrical. Of course, mechanical forces are usually electromagnetic in the last analysis, but it is convenient to distinguish between processes that are very clearly the result of electromagnetic forces and those in which any electromagnetic feature is involved in more subtle form.

Mechanical Methods. Thus, in the mechanical realm we have effects of the pressure of light. For instance, L. Spitzer, Jr., has considered the acceleration of small particles under the influence of radiation pressure in the tremendous energy outburst of a supernova. He calculates that such particles can receive from a supernova outburst from 0.01 to 1.0 billion electron volts per nucleon (proton or neutron) of each particle, within an interval of a few hours to a few weeks.

It is also postulated that the particles are held within the galaxy by an extensive magnetic field. As a result of collisions with atomic nuclei in the galaxy, the particles which have escaped collisions with stellar bodies break up ultimately into nucleons. The neutrons soon change to protons because of their finite life expectancy, and the protons are lost finally by encounters with atomic nuclei or by striking large bodies like the earth. An equilibrium condition is set up in which the number of high-energy nucleons contributed to the galaxy per unit time is equal to the number lost by the aforesaid processes. By this means, a cosmic ray intensity between 0.0001 and 0.01 of the measured intensity is predicted, depending upon assumptions as to the frequency of nuclear collisions in the galaxy.

E. Fermi, in 1949, suggested an intriguing mechanism which may be pictured in elementary fashion by thinking of a room containing gas molecules and many hard steel spheres flying about and rebounding from one another and from the walls of the room. It will be convenient to eliminate gravity temporarily during our meditations.

According to well-understood principles of thermodynamics, the spheres will, in the last analysis, lose their energies to the gas molecules and will finally come to a state of equilibrium in which the average translational energy of each sphere will be the same as that of a gas molecule. If the spheres are sizable, let us say 10 centimeters in radius, their average velocity will then be very small compared with that of the molecules. If, however, the spheres and the walls of the room are perfectly elastic, and if the spheres have considerable velocities initially, it will be a very long time before they get to this final state of equilibrium.

Meanwhile, the spheres will seek another quasi-stationary equilibrium in which they have a velocity distribution among themselves which is like that of the gas molecules, but with an average kinetic energy of each sphere enormous compared with that of one of the molecules. This kinetic energy will be approximately equal to the total original energy of the spheres divided by their number. In other words, the spheres will have a kind of macroscopic temperature of enormous amount which diminishes extremely slowly to the final temperature representative of the true equilibrium of both spheres and gas molecules.

The quasi-equilibrium of the spheres is not an accidental phenomenon, but is an inevitable consequence of the laws of dynamics as applied to the collisions between the spheres.

Suppose now that we imagine the molecules to be reduced in number so that the chances of molecules colliding with one another are very much less than their chances of colliding with the spheres. The molecules may become "ambitious" and seek, through their collisions, to accommodate themselves to the kinetic energy of the spheres, acquiring velocities much greater than those of the spheres. This ambition, though at first sight fantastic, is not indeed illogical under the specialized conditions we have assumed—dynamical laws require it.

In the Fermi mechanism our steel spheres are replaced by bounded magnetic fields, associated with moving masses of gas in the galaxies. A magnetic field of this kind is representative of a hard elastic body, because an electric particle entering it is turned back to the region from which it came, without any loss of energy as measured in the frame of reference in which the magnetic field is at rest.

However, there are certain difficulties in the Fermi mechanism. A fast-moving charged particle loses energy by ionizing the other atoms in its path; and while the density of matter in space is very small, the loss of energy by this process

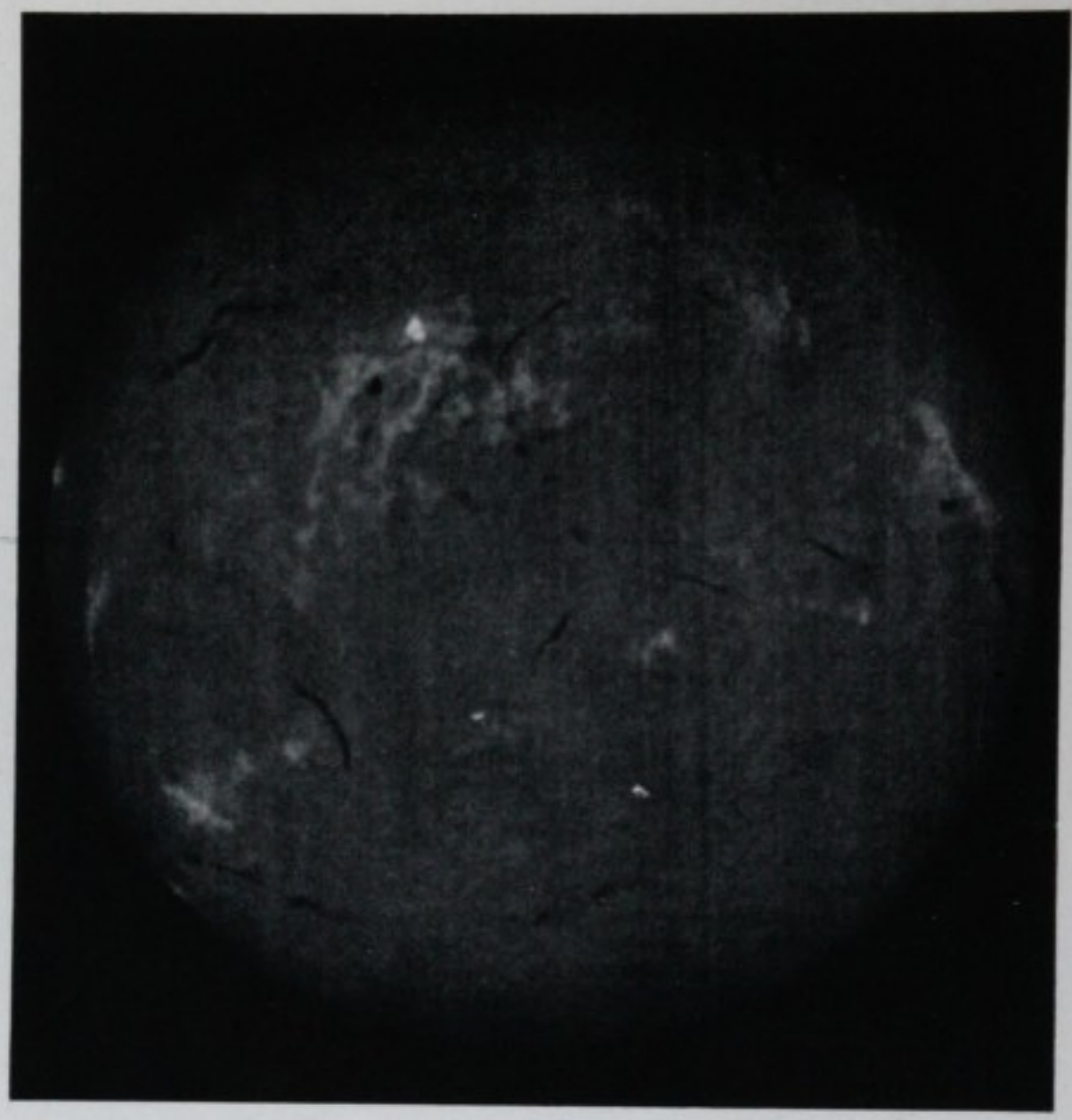
more than offsets the Fermi gain for low energies, where the ionization probability is greater. Only when a particle has attained the lower range of cosmic ray energies is the Fermi mechanism capable of taking hold to increase further the energy of the particle. In this matter, heavy particles are at a disadvantage with respect to light particles. Thus, the Fermi mechanism requires a kind of injector process to get it started, such as the suggestion of Spitzer already cited.

Then, since the average energy gained by the mechanism is only about 10 electron volts per collision, and since each particle would have only about one collision per year, about 60 million years would be necessary for a particle to acquire cosmic ray energy. During this period, it would have opportunities for collision with the nucleus of some particle in the surrounding space, and such a collision, as we know from the evidence presented by protons entering our atmosphere, would result in destruction of the particle and its conversion into mesotrons, which disappear because of their finite life.

As our quantitative knowledge becomes more complete, the strength of the evidence against the Fermi mechanism increases also, one of the most potent difficulties arising from the time necessary for the particle to acquire cosmic ray energies and the chance of its destruction during that time.

Electromagnetic Methods. The science of electricity and magnetism suggests many processes by which cosmic ray energies can be realized. Phenomena and quantities that are of negligible importance in experiments on a laboratory scale can grow to very fundamental significance in the scale of the cosmos. We can only briefly sketch some of the suggestions that have been made in this connection.

First, we could view the planets or other cosmic bodies as electrically charged to very high potentials, so that charged particles coming to them from space could acquire great energies in reaching them. It is with some comfort that one finds a fairly general method of dismissing this naive suggestion. While interstellar space contains only about one atom per cubic centimeter, there is reason to think that it is a comparatively good conductor of electricity for small electric fields. A large portion of interstellar atoms are ionized by ultraviolet starlight, and the mean free path of the ions is large because of the low density. Therefore, on a simple view of the matter, the electrical conductivity of interstellar space should be comparable with that of a completely ionized gas at atmospheric pressure and should amount, in fact, to a few per cent of the conductivity of copper. Under such conditions, any electrostatically charged body in the galaxy would become rapidly discharged.



An increase in the observed cosmic ray intensity may accompany solar flares. The bright spot in the upper left part of the sun's disk is a flare photographed in hydrogen light on April 26, 1946, at the McMath-Hulbert Observatory.

A rotating, magnetized, conducting sphere experiences electrodynamic forces resulting from the rotation of its substance in its own magnetic field. Such a rotating sphere develops a potential difference between its axis and its equator. A star the size of our sun, possessing a magnetic field like that attributed to the sun until recently, would acquire a potential difference of about three billion electron volts when rotating in a nonconducting medium. For a magnetic star, such as was cited by H. W. Babcock, with a field of some 6,000 gauss at the pole and twice the sun's radius, the potential difference would be of the order of a thousand billion volts for the same angular velocity.

These potential differences would not be completely annulled by the electrical conductivity of interstellar space since they would be continually rejuvenated by the rotation of the star. They would be modified depending upon the ratio of the conductivity of space to the conductivity of the star itself. Under suitable conditions, such a rotating star could shoot out from one of its poles charged particles which at great distances would show cosmic ray energies.

Recognizing the existence of violent magnetic disturbances on stars, akin to the growth of sunspots with their accompanying magnetic fields, the writer, some 20 years ago, suggested that such phenomena might result in cosmic ray energies. The mechanism is quite analogous to that of an ordinary electrical transformer, where we have a changing magnetic field threading through a wire circuit and inducing therein an electromotive force which drives the current through the circuit. The actual circuit itself is not necessary for the realization of the electromotive forces, and if there be charged particles in the vicinity of the changing magnetic field, they will be whirled around by the electromagnetic forces even though they do not form part of a material circuit. It seems that cosmic ray energies can readily be acquired by processes of this kind.

Recently, the foregoing mechanism has been extended to galaxies, where magnetic fields of the order of 7×10^{-6} gauss are recognized as existing. On the supposition that these magnetic fields have grown from zero, it appears that a charged particle which had zero energy when the field was zero would acquire energy continually, and could attain an energy greater than 10^{19} electron volts

by the time the field had risen to 7×10^{-6} gauss. The complete story of the possibilities in this matter involves the lifetime of a cosmic ray, and the conditions pertaining to the case where the magnetic field has already attained a finite value at the time the particle, as a result of becoming charged, starts to acquire energy.

It is also known that if an electrical conductor in a magnetic field is removed from the field, the conductor will tend to carry the magnetic field with it. What really happens is that the change of magnetic flux which would occur in the conductor, if it simply left the magnetic field behind, introduces electromotive forces and so current. This forms a new magnetic field which just replaces the loss of magnetic flux that would otherwise have resulted from the departure of the conductor from the original field. A. Unsöld has called attention to the fact that, in those huge solar cataclysms in which a mass of matter is seen to be hurled from one portion of the sun's surface and to fall back upon another, we have a condition favorable for changing magnetic fields. If such a mass of matter is conducting and starts from a place where there is a magnetic field, it will pursue its course in the cataclysm, carrying the magnetic field with it until it eventually splashes once more into the sun, resulting in the annihilation or the dispersal of the magnetic field which it carried. The rapid change in magnetic flux through the regions of space in which the cataclysm occurs provides for the birth of electrical forces which can give cosmic ray energies to charged particles.

Another method of accelerating charged particles has been suggested by D. H. Menzel and W. W. Salisbury and has been further developed by E. M. McMillan. It depends upon energy that is electromagnetic in nature, but with very low frequencies of only a few cycles per second and existing only in the extreme outer portion of the solar corona. Such low-frequency waves may arise from large magnetic disturbances initiated by solar flares and propagated through the corona. Sparsely distributed ions in the space around the sun (and other flare-type stars) might be accelerated to cosmic ray energies if a mechanism of this kind actually exists.

But if the general cosmic radiation originates in stellar flares, why does it come nearly uniformly from all directions? This difficulty attends any theory that involves the stars as the origin of cosmic rays. Therefore, it has become customary to postulate an extensive magnetic field extending throughout the whole galaxy. This field is supposed to be weak but sufficiently extensive to curl up the paths of the cosmic ray particles in such fashion as to prevent their escape from the galaxy, and at the same time to provide, as the result of successive reflections at the boundaries of the galaxy, for a condition in which an observer on our earth, for example, receives rays with approximately equal intensity from all directions.

If cosmic rays are purely stellar in origin, however, we might expect cosmic radiation from the sun to outweigh that from the other stars by something like the extent to which sunlight exceeds starlight. This is not the case, and radio noise from the stars in general seems to outweigh that from our sun; therefore, Unsöld is driven to assume that the sun is not typical in these matters and that the cosmic ray activity of many stars may be very much larger than that of the sun.

An alternative not inconsistent with the possibilities is to attribute practically the whole observed cosmic radiation to the sun itself. For this, the magnetic field of the space around the sun would have to confine cosmic rays to the general vicinity of the solar system, with boundary reflections producing the observed near-uniformity from all directions. It is a fact that unusual solar activity is accompanied by variations in measured cosmic radiation. Thus, for example, in July of 1946 an exceptionally large flare developed on the sun, and during this period a change of as much as 20 per cent in cosmic ray intensity was observed by stations of the Carnegie Institution of Washington distributed in various localities.

Abundances of the Elements. Suppose that, regardless of the methods of origin and places of origin of the rays, different substances contributed to the rays in proportion to the amounts of the substances present. If the rays came directly to us from their places of origin, the proportions of atoms of different kinds in the primary rays should reflect the abundances of the different kinds of atoms in the universe.

If, however, the rays are confined by the boundaries of a magnetic field coextensive with the galaxy, like fish kept in a gigantic pool, they will increase in numbers without limit. But each fish will die eventually, and a state of equilibrium will finally be reached in which the density of fish is such that the number that die per year will equal the number thrown into the pool. For a given rate of supply to the pool, the ultimate density will be greater, the greater the life of the fish. If fish of different kinds have different lives, their ultimate relative numbers will reflect their relative lifetimes as well as the rate at which they are thrown into the pool.

Death occurs to a cosmic ray when, in its wanderings through the galaxy, it strikes another atomic particle and disintegrates into mesotrons, and these in due course decay into electrons and neutrinos. The chances of collision are small; a cosmic ray may travel for many millions of years without hitting another atomic nucleus and dying. However, a larger atom will collide more frequently than a smaller one, and so lifetime considerations will tend to favor the lighter particles.

The observed relative abundances are:

Element	*Cosmic Rays*	*Sun, Stars, Interstellar Matter*
H	100,000	100,000
He	25,000	10,000
C, N, O	900	130
Heavier elements	10	15

This table does not favor the light elements in relation to heavy ones, although carbon, nitrogen, and oxygen appear to be relatively more abundant in cosmic rays than in the universe as a whole. However, the mechanisms of acceleration may act more strongly on one atom than on another, and there is, after all, very little reason to suppose that the atoms of different elements have an equal chance of receiving cosmic ray energies.

Nevertheless, one cannot doubt the importance of obtaining further more definite knowledge of the relative abundances of elements in the primary cosmic rays, and of the relative energies acquired by the different kinds of particles. From data of this kind, combined with further studies of such phenomena in the cosmos as a whole, we may hope some day to understand in greater detail all the processes involved in the life histories of these rays from the time of their creation from ordinary matter to their entry into our atmosphere.

(The End)

FACING PICTURE: The great planetary nebula NGC 7293, photographed in red light with the 200-inch Hale telescope. Like the several hundred other planetary nebulae now known, this ring-shaped cloud of gas and dust is illuminated by the very hot central star, from which ultraviolet light causes the nebula to shine by fluorescence.

Distant about 600 light-years from the earth, NGC 7293 is one of the nearest and brightest of the planetary nebulae. Located in Aquarius at $22^h\ 27^m.0$, $-21°\ 06'$ (1950), it can be seen in a small telescope as a nearly featureless ring. It is 15 minutes of arc in length.

Note the peculiar spoke-like details near the inner rim of the ring, and less conspicuous in the cloud itself. This peculiar structure was first observed in 1938 by W. Baade with the 100-inch Mount Wilson telescope. It is not yet known whether the "spokes" are falling toward the central star or have been ejected from it. Comparison of photographs taken a few years hence with the earlier plates should settle this question. Mount Wilson and Palomar Observatories photograph.

Amateur Astronomers

Report of the Southeast Region Convention

THE THIRD CONVENTION of the Southeast Region of the Astronomical League opened Saturday afternoon, April 24th, at the Bradley Observatory of Agnes Scott College in Decatur, Ga., when 116 persons registered at a reception given by their host, the Atlanta Astronomy Club. In all, eight member organizations and two members-at-large answered the roll call.

It was a pleasure to hear first from Rolland R. LaPelle, president of the league, who described its purposes and problems, and discussed publicity and ways of building up club memberships. Lewellyn Evans told of the mechanics of Chattanooga's Schmidt camera and its use in searching for natural earth satellites, and Dr. W. A. Calder, of Bradley Observatory, gave a "high-fidelity" account of activities in radio astronomy.

At the second session, Hugh Ivey, of the Engineering Experiment Station of the Georgia Institute of Technology, explained clearly and concisely how a spectroscope works and what it tells. This paved the way for the talk at the banquet that evening by Dr. K. N. Rao, who is now on the faculty of the University of Tennessee. Dr. Rao spoke on "The Spectra of N-type Stars." Dr. Karel Hujer, of Chattanooga, followed with informative data on "A Family of Eclipses." He showed slides of various eclipse expeditions, which emphasized the international ties between astronomers. Arthur Jones' film and live commentary on the making of the 20½-inch Chattanooga primary mirror and the difficulties encountered with its Cassegrainian secondary proved valuable.

In spite of a record rainfall in the late afternoon, skies cleared enough for observing with the 30-inch Beck telescope at the conclusion of the day's program.

The closing session began with a report on Mars by P. O. Parker, of Decatur, Ga. A short time was devoted to an oral quiz prepared by B. L. Harrell, of Gadsden, Ala., to which the audience responded well. H. R. Hudson's discussion of space travel problems proved exceptionally sensible and "down to earth."

The regional chairman for next year, Mr. Jones, was introduced, and he in turn presented the other newly elected officers: Dr. R. E. Angell, St. Petersburg, Fla., vice-chairman; C. H. Holton, Atlanta, Ga., secretary; Harry Johnson, Atlanta, treasurer; Lewellyn Evans, Chattanooga, regional representative; and Mrs. A. J. Bieker, St. Petersburg, alternate regional representative.

After adjournment, a motorcade went to see J. B. Stusak's 12-inch and the writer's 16-inch telescopes (see *Sky and Telescope*, March, 1953, page 136).

W. H. Close, secretary
Southeast Region

MONTREAL CENTRE OBSERVATORY

The Montreal Centre of the Royal Astronomical Society of Canada now has a building, placed at its disposal by McGill University, for use as an observatory and meeting place. Members are co-operating in the construction of a dome on the roof of the building, which will house their 6-inch refractor. A drive is being conducted to raise five thousand dollars to carry out the work. Contributions of building materials as well as money will be accepted, and may be sent to C. Yarnell, 2290 Girouard Ave., Montreal 28, Que., Canada.

AAVSO AWARD TO PERCY W. WITHERELL

The American Association of Variable Star Observers, at its spring meeting held in New York on May 7-8, presented its 12th merit award to the well-known Boston amateur, Percy W. Witherell. For nearly a quarter of a century Mr. Witherell has served as treasurer of the AAVSO, and recently has been very active in the drive to raise a permanent endowment for the association.

ST. PAUL ECLIPSE INVITATION

The St. Paul Telescope Club will be host to astronomers and other visitors who come here to observe the total eclipse of the sun on June 30th. Headquarters will be at Macalester College. All visitors are invited to register there, either in person or by mail addressed to the St. Paul Telescope Club, Macalester College, St. Paul 5, Minn.

We have selected as our viewing site the University of Minnesota airport, which is located outside the metropolitan area north of the Twin Cities and near the center line of totality. Besides an excellent view of the eastern horizon, electric power is available for instruments and there are ample parking and viewing areas. Our headquarters will have directions on how to reach the site, as well as other information. Special busses will run from the bus depot in downtown St. Paul to the site.

We have arranged with the airlines for plane space for those who wish to view the eclipse from the air. The approximate cost will be $8.00. Requests for reservations for this space can be made directly to the airline ticket offices at Wold-

The convention of the Southeast Region of the Astronomical League, Bradley Observatory, April 24, 1954. Photo by Lee Studio.

Chamberlain Field, Minneapolis, Minn.

A special meeting of the St. Paul Telescope Club will be held at Macalester College on Tuesday evening, June 29th, at 7:30 p.m. Dr. H. Percy Wilkins, visiting English astronomer, will speak. All visitors are invited to attend.

MRS. R. E. ENGLISH, secretary
St. Paul Telescope Club

SPOKANE SUMMER MEETINGS

During the summer months the Amateur Telescope Makers of Spokane, Inc., will meet in the Finch Arboretum, on the last Friday of each month. The building is on the outskirts of Spokane and offers a fine view of the sky for observing. Further information may be had from the secretary, Mrs. Ella Mortensen, 1519 W. Augusta, Spokane 12, Wash.

BURNHAM SOCIETY PUBLICATION

The Chicago Astronomer is a new periodical published monthly (except July and August) by the Burnham Astronomical Society of Chicago. The first issue, for May, is four mimeographed pages, containing news of the society, notes on the Mars opposition, plans for observing the total eclipse, and a preliminary report on the brilliant fireball of March 16, 1954, which was very widely observed in the Chicago area. The editor of **The Chicago Astronomer** is Robert Johnsson, 7404 N. Seeley Ave., Chicago 45, Ill.

STELLAFANE IN AUGUST

TELESCOPE MAKERS and other interested amateurs will gather in Springfield, Vt., on Saturday, August 21st, in a revival of the famous gatherings at Stellafane, sponsored this year jointly by the Springfield Telescope Makers and the Amateur Telescope Makers of Boston.

Stellafane is on a mountaintop a few miles from Springfield, and has long been a mecca where members of the telescope making fraternity gather to display their instruments and to talk about them.

This year's meeting, outdoors and of the informal type, will be like previous Stellafanes in all respects, except that no meals will be served. There will be a large pavilion tent for shelter, and a canteen for coffee, milk, ice cream, and soft drinks. Visitors should bring their own picnic-style lunches and suppers, but fire hazard will probably permit no camp fires or cooking of any kind.

A conducted tour of the Jones and Lamson Machine Company, including the optical department of the comparator division, will start at 1:30 p.m. During the remainder of the afternoon, evening, and night, the telescopes will be set up for inspection and observing. There will probably be several informal talks.

Instruments of all types, sizes, and styles, and their accessories, should be brought along. New and old instruments are equally welcome, for there will be two generations of telescope makers present—those who have been at previous Stellafane meetings, and new enthusiasts who have never had an opportunity to attend because Stellafane gatherings have not been held for several years.

Room reservations in the Springfield area, either at Hartness House or in motels and tourist places, may be made by writing to Hartness House, attention Mr. Merryfield, Springfield, Vt. The ATM's of Boston are handling all other correspondence and finances. A registration fee of $2.00 for adults will be charged to cover grounds expenses; children with adults will be admitted free. All inquiries and registration fees should be directed to the undersigned.

JAMES W. GAGAN
Amateur Telescope Makers of Boston
Harvard College Observatory
Cambridge 38, Mass.

CORRECTION TO ECLIPSE TABLE

On page 229 of the May issue, in connection with Paul W. Stevens' article, "Events Along the Shadow Path," a table was given of the position angles of contacts and the duration of totality at the June 30th eclipse of the sun, for points in Wisconsin and Michigan within the path of totality. By an editorial error, for which Mr. Stevens was in no way responsible, the table was mislabeled. The words **northwest** and **southeast** should be interchanged in all cases.—ED.

Planetarium Notes

BALTIMORE: *Davis Planetarium.* Maryland Academy of Sciences, Enoch Pratt Library Building, 400 Cathedral St., Baltimore 1, Md., Mulberry 2370.

SCHEDULE: 3:45 p.m. Monday and Friday (Sept.-June); Thursday, 7:15, 7:45, 9:00 p.m. Admission free. Spitz projector. Director, Thomson King.

BUFFALO: *Buffalo Museum of Science Planetarium.* Humboldt Parkway, Buffalo, N. Y., GR-4100.

SCHEDULE: Sunday, 2:00 to 5:30 p.m. Admission free. Spitz projector.

CHAPEL HILL: *Morehead Planetarium.* University of North Carolina, Chapel Hill, N.C.

SCHEDULE: Daily at 8:30 p.m.; Saturday and Sunday at 3:00 p.m. Zeiss projector. Manager, A. F. Jenzano.

CHARLESTON, W. VA.: *Hillis Townsend Planetarium.* Public Library Building, Charleston, W. Va.

SCHEDULE: Saturday, 11:15 a.m. Special showings on request. Admission free. Spitz projector. Director, Louise L. Morlang.

CHEROKEE, IA.: *Sanford Museum Planetarium.* Sanford Museum, 117 E. Willow St., Cherokee, Ia.

SCHEDULE: Monday, 8 p.m. (except August). Admission free. Spitz projector. Director, W. D. Frankforter.

CHICAGO: *Adler Planetarium.* 900 E. Achsah Bond Drive, Chicago 5, Ill., Wabash 2-1428.

SCHEDULE: Mondays through Saturdays, 11 a.m. and 3 p.m.; Sundays, 2:00 and 3:30 p.m. Zeiss projector. Director, Wagner Schlesinger.

KANSAS CITY: *Kansas City Museum Planetarium.* 3218 Gladstone Blvd., Kansas City 1, Mo., Chestnut 2215.

SCHEDULE: Saturday, 3:00 p.m.; Sunday, 3:00 p.m. Spitz projector. Director, Charles G. Wilder.

LOS ANGELES: *Griffith Observatory and Planetarium.* Griffith Park, P. O. Box 27787, Los Feliz Station, Los Angeles 27, Calif., Olympia 1191.

SCHEDULE: Daily, 3:00, 8:00, and 9:15 p.m.; extra shows Saturday and Sunday at 4:15 p.m. Zeiss projector. Director, Dinsmore Alter.

NASHVILLE: *Sudekum Planetarium.* Children's Museum, 724 2nd Ave. S., Nashville 10, Tenn., 42-1858.

SCHEDULE: Sunday, 2:45, 3:30, 4:15. Spitz projector. Supervising lecturer, James C. Foster.

NEWARK: *Newark Museum Planetarium.* 49 Washington St., Newark 1, N. J., Mitchell 2-0011.

SCHEDULE: Saturday and Sunday, 2:30 and 3:30 p.m. Admission free. Spitz projector. In charge, Ray Stein.

NEW YORK CITY: *American Museum—Hayden Planetarium.* 81st St. and Central Park West, New York 24, N. Y., Trafalgar 3-1300.

SCHEDULE: Mondays through Fridays, 2, 3:30, and 8:30 p.m.; Saturdays, 11 a.m., 1, 2, 3, 4, 5, and 8:30 p.m.; Sundays and holidays, 1, 2, 3, 4, 5, and 8:30 p.m.; Wednesdays and Fridays, 11 a.m., for school groups. Zeiss projector. General manager, J. M. Chamberlain.

PHILADELPHIA: *Fels Planetarium.* Franklin Institute, 20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Locust 4-3600.

SCHEDULE: Tuesdays through Sundays, 3 p.m.; Saturdays, 11 a.m.; Saturdays, Sundays, and holidays, 2 p.m.; Wednesdays, Fridays, and Saturdays, 8:30 p.m. Zeiss projector. Director, I. M. Levitt.

PITTSBURGH: *Buhl Planetarium and Institute of Popular Science.* Federal and West Ohio Sts., Pittsburgh 12, Pa., Fairfax 4300.

SCHEDULE: Mondays through Saturdays, 2:15 and 8:30 p.m.; Sundays and holidays, 3:15 and 8:30 p.m. Zeiss projector. Director, Arthur L. Draper.

PORTLAND, ORE.: *Oregon Museum of Science and Industry Planetarium.* 908 N.E. Hassalo St., Portland 12, Ore., East 3807.

SCHEDULE: Saturday and Sunday, 3:00 p.m.; Wednesday, 4:00 p.m.; Saturday show for children only, 10:30 a.m. Spitz projector. Director, Stanley H. Shirk.

PROVIDENCE: *Roger Williams Planetarium.* Roger Williams Park Museum, Providence 5, R. I., Williams 1-5640.

SCHEDULE: Wednesday at 3:30 p.m.; Saturday at 10:30 a.m., 2:30 and 3:30 p.m.; Sunday, 2 to 5 p.m. Admission free. Spitz projector. Director, Maribelle Cormack.

SAN FRANCISCO: *Morrison Planetarium.* California Academy of Sciences, Golden Gate Park, San Francisco 18, Calif., Bayview 1-5100.

SCHEDULE: Daily (except Monday and Tuesday) at 3:30, 7:30, and 9 p.m.; also at 2 p.m. on weekends and holidays. Academy projector. Manager, George W. Bunton.

SPRINGFIELD, MASS.: *Seymour Planetarium.* Museum of Natural History, Springfield 5, Mass.

SCHEDULE: Tuesdays, Thursdays, and Saturdays at 3 p.m.; Tuesday evenings at 8 p.m.; special star stories for children on Saturdays at 2 p.m. Admission free. Korkosz projector. Director, Frank D. Korkosz.

STAMFORD: *Stamford Museum Planetarium.* Courtland Park, Stamford, Conn.

SCHEDULE: Sunday 4:00 p.m. Admission free. Spitz projector. Director, Ernest T. Luhde.

ST. PETERSBURG: *Rice Planetarium.* 4700 Lakeview Ave., St. Petersburg, Fla.

SCHEDULE: Daily, 10:30 a.m., 2:30 and 8 p.m.; Sunday, 2:30 p.m. Spitz projector. Director, Laban Lacy Rice.

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Research and the Small Astronomy Department

While newspapers seem to give the impression that astronomical research in America is carried out only at those few observatories that have giant telescopes, all astronomers know that much valuable work is done in small departments at many colleges and universities, although often under great difficulties. The support of astronomy at small colleges is important, not only for the contribution that research makes to enlarging knowledge, but also because research activity can scarcely fail to vitalize the astronomy teacher and his teachings.

How such research can be promoted, and how the National Science Foundation can assist in this, were the themes of a three-day conference held at Sproul Observatory in Swarthmore, Pa., on April 19-21, under the joint sponsorship of Swarthmore College and the National Science Foundation. The 25 participating astronomers represented a variety of types of educational institution and attended from places as far separated as New Hampshire and Arizona, Georgia and the state of Washington.

A chief difficulty of the small astronomy department in carrying out research is limited manpower. Often the department comprises only one person, with a heavy teaching load that may include courses in physics or mathematics, and with administrative duties that further reduce the time and energy available for research. This problem can be solved in a practical way by adding a second instructor, thereby allowing each of the two men to devote half time to research. It was agreed that NSF research grants to such colleges would be an effective way to provide for such expansion for periods of a few years. And if these grants enabled the employment of student assistants, additional advantages would follow for both departments and students.

The research facilities of small astronomical departments are ordinarily very limited, and much discussion was devoted to how they can be increased by cooperation with larger institutions. Valuable research can be carried out with photographs and spectrograms made during a short visit to a large telescope. And, often, good existing observational material is available and could be borrowed for study. One particularly successful instance is the department at the University of Minnesota, where, although there are no observing facilities for the purpose, a majority of the known white dwarf stars has been discovered—on plates made at the Harvard, McDonald, Steward, Mount Wilson, Cordoba, and other observatories.

The importance of this kind of collaboration led to the adoption of Dr. J. J. Nassau's proposal that a list be made of about 50 observatories, giving information on what equipment and plate material would be available for co-operation and to what extent visiting workers could be received. Dr. Peter van de Kamp, of the Sproul Observatory, was named chairman of a committee to assemble this information.

One of the chief stimuli to an astronomer's research activity is varied contact with other astronomers, and the meeting explored many means of extending such contacts, because they are of special value in overcoming the isolation often felt by staff members of small departments. Grants for research leaves, exchange professorships, fellowships, and professorships at small institutions for retired but active astronomers, all were discussed as ways in which NSF support would be important. Everybody agreed on the value of informal neighborhood meetings, at which astronomers from different observatories meet regularly to discuss results, problems, and plans. Another interesting possibility is that several small institutions, within easy travel distance of one another, pool their resources to establish a joint astronomy department.

Dr. Raymond J. Seeger, of the NSF, described its policy toward the support of research and education. The great potential benefit that NSF support has is brought out by the results of the earlier Office of Naval Research program with much smaller funds, when "never before had so little money done so much good for so many astronomers." Dr. Seeger pointed out that the cost of administering small grants is proportionately much more than for larger grants, so that a research project should be sufficiently definitive that support may be given for its entire duration (up to five years).

Furthermore, the equipment purchased from a research grant belongs solely to the institution. Observatories can therefore now consider the possibility of NSF aid for the renovation or enlargement of observing facilities. NSF funds can also be used to publish monographs.

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BOOKS AND THE SKY

GALILEO GALILEI: DIALOGUE ON THE GREAT WORLD SYSTEMS

Giorgio de Santillana, editor, from T. Salusbury's translation. University of Chicago Press, Chicago, 1953. 506 pages. $12.50.

GALILEO GALILEI: DIALOGUE CONCERNING THE TWO CHIEF WORLD SYSTEMS—PTOLEMAIC AND COPERNICAN

Stillman Drake, translator. University of California Press, Berkeley, 1953. 496 pages. $10.00.

ASTRONOMERS have long been aware that Galileo's great classic on the Ptolemaic and Copernican systems of the universe was generally unavailable to the English-reading public, save for the extremely rare Salusbury version which was published in 1661, and which has never been reprinted. Now two independent English renderings are available, one a wholly new translation by Stillman Drake, and the other a revised edition of Salusbury's translation prepared by Giorgio de Santillana.

We must certainly deplore the duplication of effort involved here, but—however much we may wish that either Mr. Drake or Mr. Santillana had known of the other's work and had translated other works of Galileo like the **Saggiatore** or the book on sunspots—we welcome the availability of Galileo's book in modern dress for the 20th-century reader.

Galileo's dialogue on the two chief systems of the world touched off a controversy that has tended to obscure the scientific merits of the book itself. For despite the imprimatur granted by the ecclesiastical authorities, Galileo was summoned before the Inquisition, the book was placed on the "Index of Forbidden Books," and Galileo abjured the "heresy" of the Copernican philosophy. From that day to this, no one has ever written about this book dispassionately; the literature either becomes apologetic (for the conduct of the Church or of Galileo—who is sometimes branded a "coward" for his abjuration) or leaps to the attack of those who sought to restrict the freedom of thought, who held that scientific truth could be determined in any way other than by the test of experiment or observation.

In 1952 Pope Pius XII referred to "the modern concept of the science of astronomy, which has been the ideal of so many great men in the past: Copernicus, Galileo, Kepler, Newton." This may be considered an official recognition of the role in the growth of modern science of one of the Roman Catholic Church's most distinguished sons. Although Galileo's book had been removed from the "Index" early in the 19th century, his name had not heretofore been mentioned with approbation in any papal pronouncement or address. We may, therefore, conclude that the controversy has now only a historical interest, perhaps as a case history of the freedom of the mind. But if we wish to use this case history, we must have the correct story, and the attempt to get it brings us right back to the old controversy.

For example, it is often said that in 1616 Galileo was told by the Inquisition "not to teach or discuss, in any way whatsoever, verbally or in writing, the Copernican system, otherwise proceedings would be taken against him by the Holy Office"; and the Inquisitors produced a document with these words at his trial. Galileo had possession of a document of 1616 written by Cardinal Bellarmine stating that he had been notified only that "the doctrine attributed to Copernicus is contrary to the Holy Scriptures, and therefore cannot be defended or held." Galileo's abjuration, after examination by the Inquisition, contained the words that he would, in the future, ". . . not hold, defend, or teach in any way whatsoever, verbally or in writing, the said doctrine. . . ." Mr. Drake, in his very short preface, says that the passage of which this is a part (and which had been prepared for Galileo to sign), "was essentially true," and implies that Galileo was, therefore, technically guilty. Mr. Santillana, in his historical introduction, unhesitatingly pronounces the Inquisitors' document of prohibition (containing the words ". . . or teach in any way whatsoever, verbally or in writing, . . .") a "falsification" and raises the question only as to whether it "was fabricated in haste in 1632, in order to have a case, or had . . . been planted with consummate deliberation in 1616."

According to Cardinal Bellarmine's document, Galileo was well within the limits of the proscription when he wrote his dialogue; according to the other document, he was not. So important is the whole question of the trial and condemnation of Galileo that Mr. Santillana has prepared a separate book on this question which has been announced for publication by the University of Chicago Press.

Galileo's dialogue presents arguments for the old science and the new: the Ptolemaic astronomy and the Copernican, the old Aristotelian mechanics and the new dynamics that had been begun in late medieval times and which Galileo himself was to bring to first fruition. There is no question but that Copernicus wins the fight. The astronomer of today has the greatest difficulty in understanding the older astronomy and mechanics, and a welcome feature of the Santillana-Salusbury rendition is an able presentation of the main features of the astronomy of Ptolemy and of Copernicus, with splendid diagrams, prepared by William Stahlman. I have no hesitation in recommending Stahlman's contribution as the most accurate and concise view of these two astronomical systems in print in the English language.

Another valuable feature of the Santillana-Salusbury version is the extensive series of explanatory footnotes. Taken by themselves, they constitute a veritable treatise on early 17th-century astronomy and dynamics, and they help the reader to understand the arguments of Galileo and their significance. Mr. Drake has

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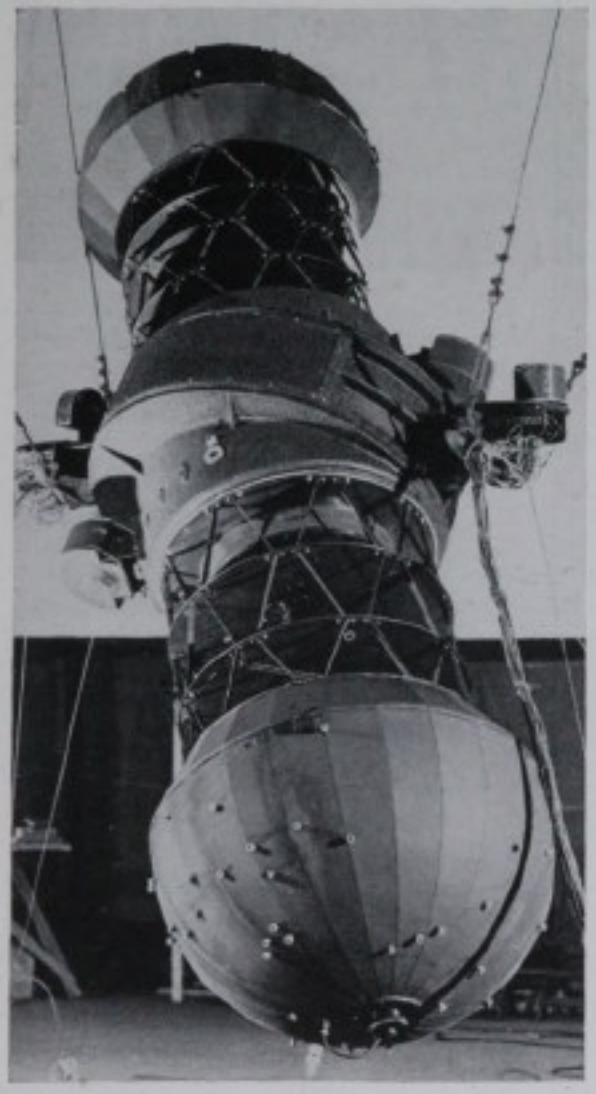
a relatively short series of end-notes; wholly apart from the inconvenience of having to skip back and forth from one part of the book to the other, the reader will find that—useful as Mr. Drake's notes are—there is a need for more detailed explanations, a need made all the more apparent by a comparison of the two editions.

Mr. Santillana's notes are of two sorts; some are the results of his original research, while others summarize investigations made by other historians of science. Save for references to the Favaro and Strauss editions in Italian and German, Mr. Drake gives practically no indication of an awareness that many of the major questions discussed by Galileo have been the subject of research by very able historians of science and astronomy. For example, Mr. Drake is concerned by Galileo's apparent adoption of a value of the acceleration of gravity of about 467 rather than 980 centimeters per second per second, and compares this poor value to Galileo's "observations of bodies moving on inclined planes (**Two New Sciences,** pages 178-179) [which] were carried out with such skill that it is hard to accept so gross an error on his part." But a study of the recent literature on Galileo's dynamics (as presented, for example, in Mr. Santillana's footnotes) shows that this very experiment was reported by Galileo with an assumption of far greater accuracy than an actual performance would indicate.

Galileo's presentation of the Copernican system suffers in our eyes from several major defects which were remedied by the work of Newton and others. First of all, Galileo did not accept (if indeed he even knew about) the laws of Kepler, and so the simplicity of the Copernican system as modified by the adoption of elliptical orbits is not found here. Hence, there was denied to Galileo any concept of central forces and his dynamics is rather based on a kind of generalized, or not too clearly defined, "rotational inertia." Even the possibility of an attractive force of the moon to produce tides is explicitly rejected by Galileo. Finally, of course, the Galilean contribution to what is called the Galilean-Newtonian dynamics is not at all clearly formulated; the later version in the **Two New Sciences** is vastly improved. The reason is, perhaps, that the dialogue on the two systems of the world was written for a less technical audience and that, furthermore, many of Galileo's concepts appear in it in a transitional form which he later improved.

Mr. Drake has made a completely fresh translation, in the style and language of our own day. It is readable, accurate, and has a certain literary flavor. Mr. Santillana has revised the Salusbury version because he believed, "Only Salusbury's Jacobean prose could do some justice to the pace and rhythm of the original." Each reader will have to decide for himself whether he prefers a 20th-century version or a rendition which attempts to retain a flavor of the times when the book was still influencing scientific thought.

The relative advantages of the two



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books are as follows: Both Mr. Drake's version and the Salusbury-Santillana version are accurate and readable, but one has a modern ring to it while the other retains a sense of the past. The commentaries of Santillana and the astronomical supplement and diagrams of Stahlman are indispensable to an understanding of Galileo's text; on the other hand, the Drake version contains the postils or marginal summaries of the original, omitted in the Santillana edition, which aid the reader considerably in following the argument.

I suspect that the serious student will compare both renditions whenever he studies any particular question and will find that in many cases such a comparison may clear up a difficult point. Such an effort is worth the trouble; I believe that if any single book marks the beginning of our modern science by challenging the older concepts and explanations and demanding a consistent approach to nature in nonscholastic terms, that book is Galileo's **Dialogue**, one of the foundations of our modern astronomy.

I. BERNARD COHEN
Harvard University

MAHARAJA SAWAI JAISINGH II OF JAIPUR AND HIS OBSERVATORIES

M. F. Soonawala. Jaipur Astronomical Society, preface dated 1952. Sold by Vani Mandir, Sawai Man Singh Highway, Jaipur, India. 43 pages. 2 rupees.

THIS BOOK fills a gap in publications on the history of astronomy. Although several descriptions of ancient Hindu astronomy have appeared (see the bibliography in chapter VI of Otto Neugebauer's **Exact Sciences in Antiquity**), there seems to be no complete discussion of the astronomical activities of Jai Singh early in the 18th century.

The book's four chapters include respectively, Jai Singh's life and historical background, his astronomical sources and contemporary collaborators, an astronomical explanation of the construction of his great stone instruments, and a circumstantial description of them. Photographs are shown of all the important instruments at Jaipur; and there are drawings of the observatories at Delhi, Ujjain, and at Benares. There is a portrait of Jai Singh and a photograph of one page of his star catalogue.

Jai Singh spent most of his life involved in the political turmoil after the death of the great Indian emperor, Aurangzeb (1707). Born about 1686, he became ruler of the city Amber in 1699. In 1728 he founded and designed a new capital city, Jaipur, which he governed until his death in 1743. Himself a Hindu, he owed allegiance during most of his life to Moslem rulers, under whom he tried to extend his personal dominions by war and intrigue.

His interest in astronomy stemmed from astrological predilections and a desire to reform the calendar and improve eclipse predictions. He was familiar with the ancient Hindu astronomical text **Surya Siddhanta** and with Nasir al-din's **Ilkhanic Tables** and translation of Euclid's **Elements.** His assistant, the linguist Samrat Jagganath, helped him translate from Arabic into Sanskrit the **Elements** and Ptolemy's **Almagest.** Another assistant, Pundit Kewal Ram, translated into Sanskrit a set of logarithmic tables and the astronomical tables of Ulugh Beg and Lahire. Jai Singh was aided by several learned Jesuits, one of whom (P. Manuel de Figueiredo) he sent to Europe about 1730 for books and instruments. His library even contained a copy of Flamsteed's **Historia Coelestis.**

Jai Singh erected his first observatory at Delhi, where, it is said, he observed star positions nightly for seven years (1724-1731). His first instruments, made of brass and based on those of Ulugh Beg, proved too small and unsteady, so he constructed much larger ones of stone. Noting discrepancies between his observations and the positions of the moon, planets, and stars calculated from European tables, he decided that the latter might be inaccurate, due to observations made with small-sized instruments. His own tables, the **Zij-i-Muhammad Shahi** (1733), of which there are copies in Jaipur and the British Museum, are said to have satisfied his own observations much better.

Unfortunately, Soonawala does not discuss in any detail the accuracy of Jai Singh's observations or the contents of his tables. According to E. B. Knobel, **Ulugh Beg's Catalogue of Stars,** page 93, the tables of Jai Singh merely give the magnitudes and positions of 1,018 stars copied from Ulugh Beg, with correction for Ulugh Beg's value of precession to the epoch 1725.

In 1734 Jai Singh constructed a second observatory, at Jaipur. Its largest instrument, the Samrat Yantra, is a huge stone right triangle with a hypotenuse about 200 feet long pointing toward the north celestial pole and a vertical side about 90 feet high. There is a semicircular scale, of radius about 50 feet and with center on the hypotenuse, onto which the sun casts the triangle's shadow during the day, so that the local apparent time can be read off. A special pointer, devised by Jai Singh himself, can be moved along the hypotenuse until its shadow also appears on the scale; its position will then give the sun's declination. Several sundials, a large brass astrolabe, and other instruments are described at length; but, again unfortunately, no mention is made of the accuracy with which the scales were engraved upon these instruments.

It is surprising that Jai Singh never used telescopes. Later he built other observatories at Ujjain, Benares, and atop a fort at Muttra. All except the last still survive. The Jaipur observatory was restored in 1901 and 1945.

CHARLES GASTEYER
Yale University Observatory

NEW BOOKS RECEIVED

NEBULEUSES GALACTIQUES ET MATIERE INTERSTELLAIRE, *Jean Dufay*, 1954. *Editions Albin Michel*, 22 Rue Huyghens, Paris 14e. 492 pages. 1,650 francs.

The closely related topics of galactic nebulae and interstellar matter are comprehensively summarized by a leading French astrophysicist, who is director of the Lyons and the Haute-Provence observatories. His discussion includes radio astronomy, obscuring material in other galaxies, and the question of the absorption of light in space.

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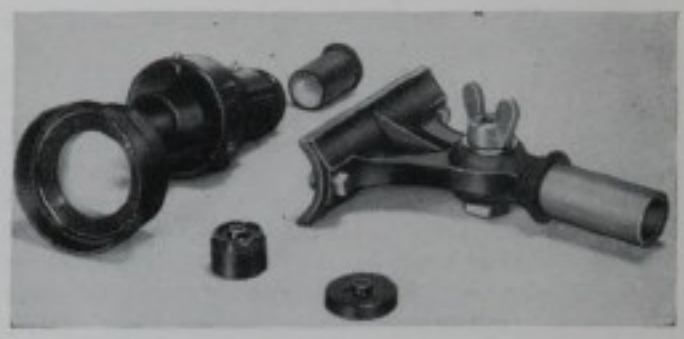

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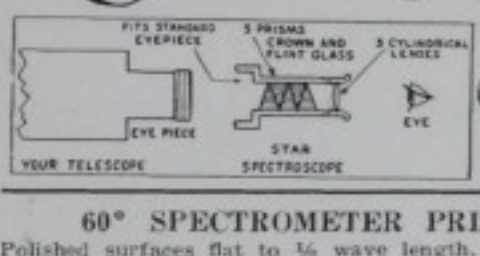

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NOTES ON BASIC OPTICS — VIII

I. Synthesis of Optical Systems

How does one develop an optical system to perform a specific function? There are two fundamental steps: first-order design and aberrational design. The first-order design determines the number and approximate location of the optical components, and preliminary values for their focal lengths and sizes. After this step has been completed, the detailed design of the individual components proceeds, to establish exact specifications for the number of individual lenses, radii of curvature, glass types, spacings, and dimensions. Usually this requires some slight modifications in the original first-order layout, and compromises between optical and mechanical requirements are often necessary.

Of course, in a practical case the situation is not quite this clear-cut. The job is greatly aided if the preliminary layout takes into account the probable form of the optical components that will be dictated by the optical requirements. Mechanical allowance should be made at the outset if forms like a telephoto or wide-angle photographic objective will be required instead of a simple achromat. At the very beginning, some knowledge should be applied of what kinds of optical elements will be needed to achieve reasonable correction for such conditions as field curvature, chromatic aberration, and distortion; this is to avoid excessive modifications after the aberrational design is complete.

Nevertheless, it is best to discuss the procedure for first-order layout before getting into the more involved aberrational design. First-order layout can suffice for many simple optical systems, such as finder telescopes, simple projection and microscope systems, and the like, which the experimenter may want to put together with lenses salvaged from old instruments or purchased through surplus dealers.

It is obviously impossible to cover all types of optical systems here, but discussion of one not-too-complex example will be useful. Let us take a rifle scope (small terrestrial telescope) as a representative system; the requirements can be made specific, and the number of lens components is large enough to illustrate the most salient points, without being so large as to make the discussion too long.

We shall specify as the basic requirements of the rifle scope:

Magnification	4x
Exit pupil diameter	5 mm.
Eye relief	50 mm.
Over-all length	200 mm.
Field of view	7°

The magnification is determined by the intended use of the scope. A 5-mm. exit pupil is large enough to fill the day-adapted pupil of the eye, which is about 2 mm. in diameter, and allows a small amount of lateral eye freedom without being so wide as to lead to very large lenses. The eye relief is necessary for safety. The over-all length has been chosen to give a reasonably compact instrument. The field of view is large

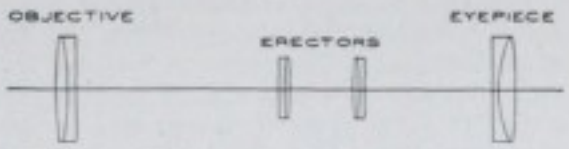

Fig. 25. The rough design of the scope.

enough to be useful, and small enough not to require wide-angle lens designs.

First the basic form of the system is laid down. We will need an objective, an erecting system, and an eyepiece. The field angles required are not extreme: 7° for the objective and 28° for the eyepiece. If we suppose that the length requirement will not lead to very short focal lengths, we can assume that a simple achromatic doublet will suffice for the objective, and a pair of doublets for the erecting system. The eyepiece will have to be more complex in the final form, but for the moment we take it to be a doublet, and we can now sketch the rough design (Fig. 25).

Next we can begin working with numbers. Experience shows that eyepieces can operate well at an aperture ratio of f/6; since the exit pupil is 5 mm., this gives us an eyepiece focal length of $6 \times 5 = 30$ mm. Multiplying the exit pupil by the magnification gives the diameter of the entrance pupil as $5 \times 4 = 20$ mm. If we are to keep within the

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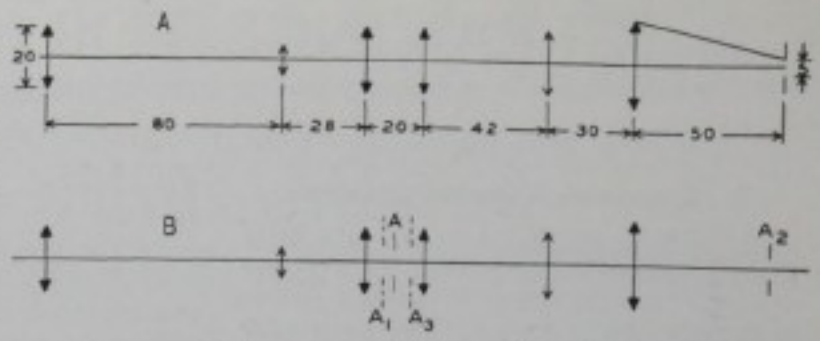

Fig. 26. The upper part (A) shows the manner in which over-all length influences choice of aperture ratios. The lower part (B) illustrates the problem of satisfying pupil requirements.

over-all length requirement, we cannot adopt f/6 for the objective, since its focal length would then come out 120 mm. So we take f/4 as a reasonable aperture ratio for a doublet to cover a 7° field, giving $4 \times 20 = 80$ mm. for the focal length of the objective.

Since the angular magnification of the objective-eyepiece system is $80/30 = 2.67$x, to achieve a 4x over-all magnification our erecting system must have a linear magnification of $4/2.67 = 1.5$x. Out of the 200-mm. allowance for over-all length, we have used up $30 + 80 = 110$ mm., leaving 90 mm. for the erecting system. The conjugate object and image distances will be in the ratio 1/1.5, and let us assume that the erector lenses have collimated light between them and are separated by 20 mm. Then the object and image distances for the erectors come out $2/5 \times 70 = 28$ mm. and $3/5 \times 70 = 42$ mm., respectively. We can now redraw our first rough sketch to scale as Fig. 26A.

Let us now see if the pupil conditions are satisfied. It is usually desirable to place the aperture stop midway between the erectors, as this leads to the smallest diameter erectors. If this is done in our design, we find—working toward the eyepiece end—that the rear erector will image the aperture stop at A_1 (Fig. 26B) at a distance of −13.1 mm., and the eyepiece will then image it at A_2 at an eye relief of 46.3 mm. This is fairly close to the required 50 mm.

Working toward the objective, the front erector images the aperture stop at A_3, at a distance of 15.6 mm. It will be desirable, then, to place a field lens in the objective focal plane to image this in the objective lens. The EFL of this field lens will be +28.2 mm. The guiding equation for these computations is, of course,

$$\frac{1}{d'} - \frac{1}{d} = \frac{1}{f},$$

where d' and d are the distances of image and object from a lens of focal length f.

Alternatively, if a field lens had not been placed in the objective focal plane, and if in the calculation the objective had been the aperture stop, the eye relief would have come out 60.6 mm. This could have been reduced to the desired 50 mm. by a positive field lens of 85.6-mm. focal length in the eyepiece focal plane. The aberrational design of the system would reveal which of these two solutions would lead to better imagery.

We could just as well have chosen erector lenses equal in focal length, and worked out their position and focal length to give the required linear magnification and the desired separation of object and image planes. In this case, the light between the two erectors would not be parallel. Actually, this arrangement would be cheaper to manufacture, because two lenses would be alike. We choose the other arrangement for this example because the computations are simpler.

As to lens diameters, we can proceed as follows. The diameter of the eyepiece (for the solution with eye relief = 46.3 mm.) will be $2 \times 46.3 \times \tan 14° + 5 = 28.1$ mm. The diameter of the eyepiece focal plane will be $2 \times 30 \times \tan 14° = 15.0$ mm. The diameter of the objective has already been given as 20 mm., and its image plane will have a diameter of 15/1.5 = 10 mm., since 1.5 is the linear magnification of the erector system.

The sizes of the erectors are found with the layout of Fig. 27. We already know that the image of the aperture stop formed

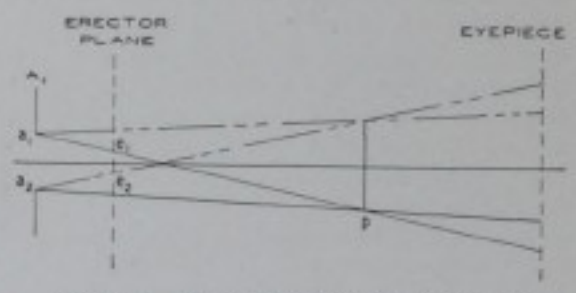

Fig. 27. The sizes of the erectors.

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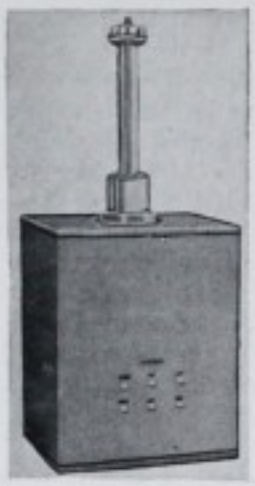

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by the rear erector, which is also the location of the image of the exit pupil formed by the eyepiece, is at A_1, −13.1 mm. from the rear erector. It is thus 30 + 42 + 13.1 = 85.1 mm. from the eyepiece. Its diameter will therefore be 5 × 85.1/46.3 = 9.2 mm., by Equation 2 of the July, 1953, installment. All the light that illuminates the image must come from this pupil image, hence we can draw the cone of rays a_1pa_2 for a point on the extreme edge of the field. The intersection of the ray a_2p with the plane of the rear erector, at e_2, gives the required diameter at this point. Its value is 9.2 + 5.8 (13.1/55.1) = 10.6 mm.

Since there is no field lens in the eyepiece focal plane, extension of the ray a_1p will also give the diameter of the eyepiece. This agrees with the figure of 28.1 mm. we had arrived at by a different means. The diameter of the front erector is found to be 10 mm., by working with its pupil image and the objective focal plane in the same way. The aperture stop between the erectors will be 9.2 × 10/13.1 = 7.0 mm. in diameter.

There is another interesting method of determining the aperture stop size. The eyepiece and rear erector constitute a telescope, since we assumed parallel light between the erectors. This telescope has a magnification of 42/30 = 1.4. The exit pupil of this telescope has a diameter of 5 mm., and hence its entrance pupil must be 5 × 1.4 = 7.0 mm., by Equation 12 of January's installment.

There is one further consideration before we turn the problem over to the lens designer; we need some method of focusing the instrument on objects at various distances. The rifle scope will require a reticle, which may be in the form of crosshairs, and this is preferably placed in the objective focal plane, to avoid magnification problems. In a rifle scope we will have windage and elevation adjustments (usually by moving the reticle with external knobs). The scale factor for these adjustments will depend upon the focal length of the objective only, if the reticle is in the objective focal plane. (If it were in the eyepiece focal plane, the scale factor would also be affected by the magnification of the erecting system.) Thus we avoid the necessity of placing a tight manufacturing tolerance on the erector focal lengths, since we do not really care if the over-all magnification of production 4x scopes is, say, 3.8x or 4.2x, so long as the windage and elevation adjustments are correct.

Now, if the reticle is in the objective focal plane, the focusing for varying distance must be done by moving the objective. Otherwise we shall have parallax (image of the outside world not falling on the reticle plane), and the reticle will appear to move with respect to the background as the eye is moved from side to side in the exit pupil. This is undesirable in any case, especially in a rifle scope, which is to be used for accurate aiming.

But moving the objective back and forth to focus prevents sealing the instrument against dust and moisture. So we adopt a telephoto form for the objective, and move only the internal negative element for focusing. This we can do with an external knob, and maintain the seal.

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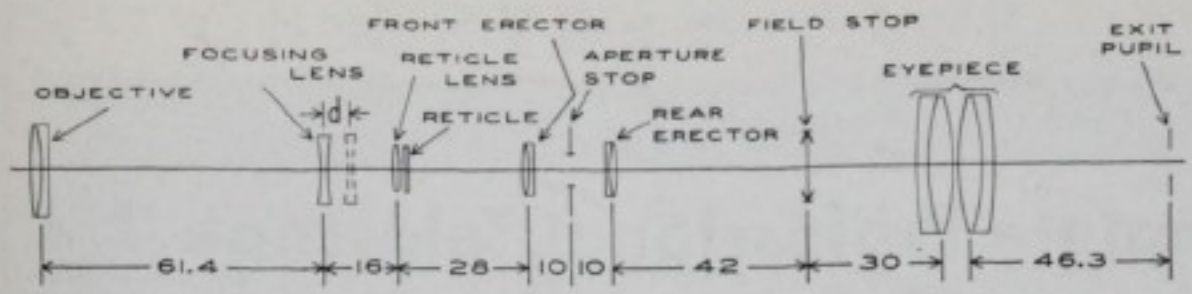

Fig. 28. After the detailed design of each lens has been completed, the finished spotting scope may have these components. The space marked "d" is that through which the negative lens is moved for focusing at various distances.

given in section **D2** of our November, 1953, installment. By educated guess, a common optical procedure, we adopt $K = 0.8$ and $f_2 = -5f_1$, and arrive at a form which is 2.6 mm. shorter than the 80 mm. of the doublet objective, and in which the negative element has to be moved 5.4 mm. along the axis to refocus from infinity to 20 yards.

Of course, when we focus for near distances, the EFL of the objective is changed, and the windage and elevation adjustments are no longer strictly correct. For this case, the change in EFL from infinity to 20 yards is 1.2 mm. or 1½ per cent. If the windage and elevation adjustment scales are determined for some intermediate range, the error resulting from focusing can be kept below one per cent.

Now we turn our layout over to a lens designer, who will determine the kind of glass, curves, and thickness required for each of the lenses. If we have made reasonably shrewd guesses as to the actual lens forms, his results will not change the appearance of our layout very much. The only significant change is the provision of two doublets instead of one in the eyepiece. The final result might look like Fig. 28, to which the following figures apply:

Lens	Diameter	EFL
Objective	20.0	76.8
Focusing	15.0	−38.4
Reticle	10.0	27.2
Front erector	10.0	28.0
Rear erector	10.5	42.0
Eyepiece	28.1	30.0
Aperture stop	7.0	——
Field stop	15.0	——
Exit pupil	5.0	——

If space permitted, we could try synthesizing other optical systems, but this example should give the reader some idea of how one goes about creating an optical system. The rifle scope described above could probably be built up out of surplus lenses and work reasonably well.

(To be continued)

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The Lunar Eclipse of July 15-16, 1954

A PARTIAL ECLIPSE of the moon will occur on the night of July 15-16, visible in the eastern part of North America; all of South America, Europe, and Africa; and in parts of western and southern Asia. The circumstances of the eclipse are shown in Fig. 1.

Although the greatest immersion of the moon in the umbra will be only 41 per cent of the lunar diameter, the spectacle will be an interesting sequel to the total solar eclipse of June 30th. The range of longitude over which the moon will be seen eclipsed in the Northern Hemisphere is roughly the same as that of the central line of the solar eclipse.

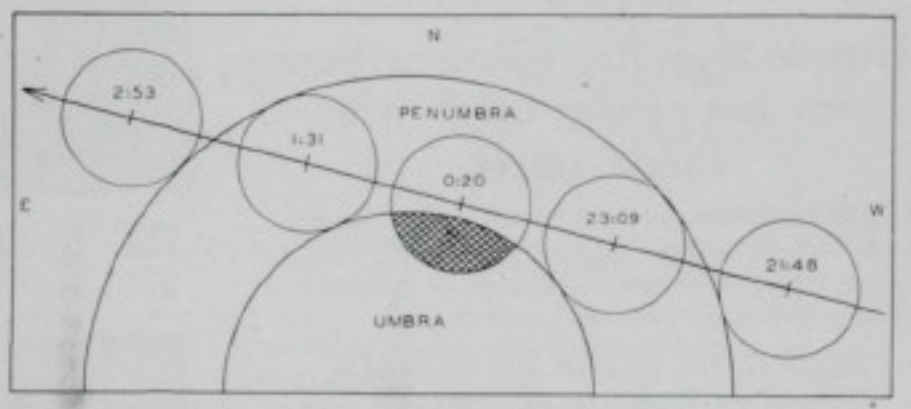

Fig. 1. The moon's path through the earth's shadow during the evening of July 15th. Universal times of the phases are shown, five hours ahead of Eastern standard time.

The evening of July 15th will afford an unusually good opportunity to see both the sun and moon above the horizon simultaneously during the eclipse. This somewhat paradoxical situation results from atmospheric refraction and from the size of the earth's umbra, which has approximately 2.7 times the apparent diameter of the moon. Circumstances for viewing the eclipsed moon before sunset are more favorable in the Northern Hemisphere because the moon passes through the northern portion of the umbra.

The map (Fig. 2) shows the zones where the moon's lower limb will be on the eastern horizon at the times of the various phases. Near the middle of the eclipse, the moon will be rising on the Atlantic seaboard. At all points along the central line of the solar eclipse of June 30th in Canada, the moon will be partly in the umbra at moonrise, while at those in the United States, the moon will be outside the umbra but deeply immersed in the penumbra, and a shading of its southwestern limb may be detected. Where the magnitude of the penumbral eclipse is −0.2 (that is, the shortest distance from the moon's limb to the edge of the umbra is 20 per cent of the lunar diameter), the darkening of the limb should be easily seen if the sky is very clear near the horizon; where it is −0.4, photography should reveal it.

The curve labeled SUN-MOON indicates where the lower limbs of both bodies will be simultaneously tangent to the horizon. In computing the position of this curve, account was taken of atmospheric refraction and solar and lunar parallax, but not dip of the horizon.

Fig. 2. The phase of the eclipse at local moonrise. West of the line MOON LEAVES UMBRA only the slight penumbral darkening can be seen.

It is of interest to see why this lunar eclipse will be visible from nearly the same geographical longitudes as the solar eclipse of two weeks earlier. Fig. 3 is a graph of the time interval from new moon to the following full moon in 1954. The

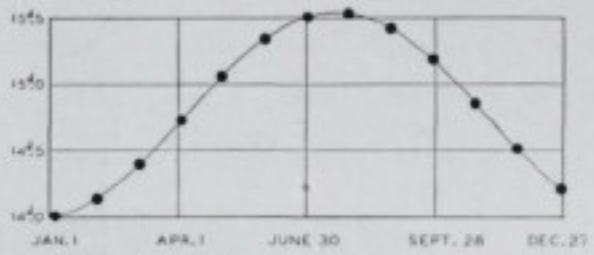

Fig. 3. The interval from new moon (on the dates indicated by dots) to the following full moon in 1954. Diagrams by Paul W. Stevens.

July 16th full moon follows the June 30th new moon by $15^d\ 12^h\ 03^m$. On the average, the moon is at the same local hour angle at consecutive new and full phases if the interval is 15.5 or 14.5 days. (A more exact statement of the effect would take note of the consequences of the sun and moon not moving along the celestial equator, but these are minor.)

When 14.0 or 15.0 days elapse between consecutive new and full moons, the local hour angles of the moon at these phases differ by 180 degrees, and the moon is generally above the horizon over opposite hemispheres of the earth. Thus the September 12, 1950, new moon was followed $14^d\ 0^h\ 52^m$ later by the September 26th full moon. On the former date, there was a total eclipse of the sun seen from east Asia; on the latter date, the moon was totally eclipsed for observers in the United States.

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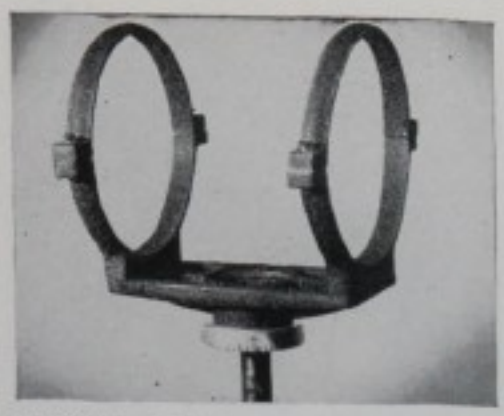

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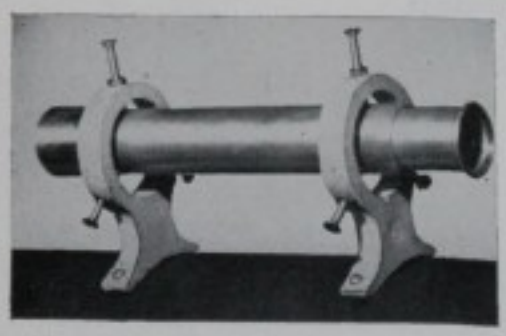

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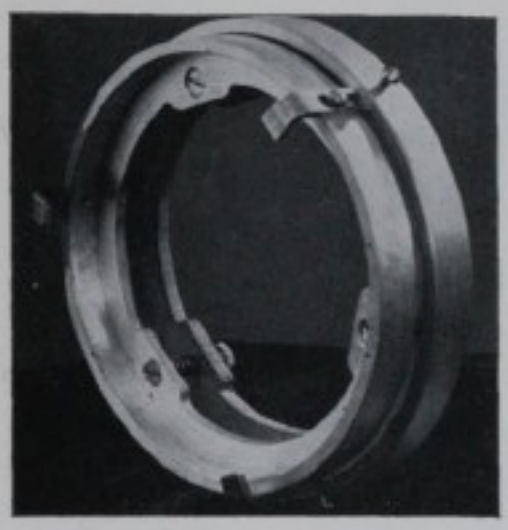

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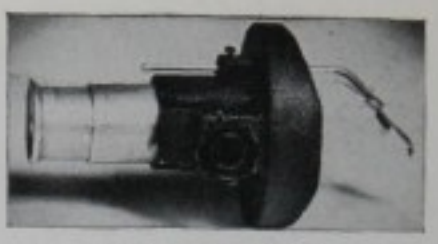

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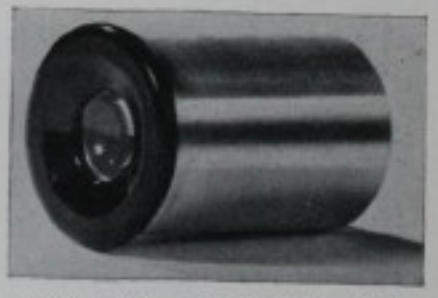

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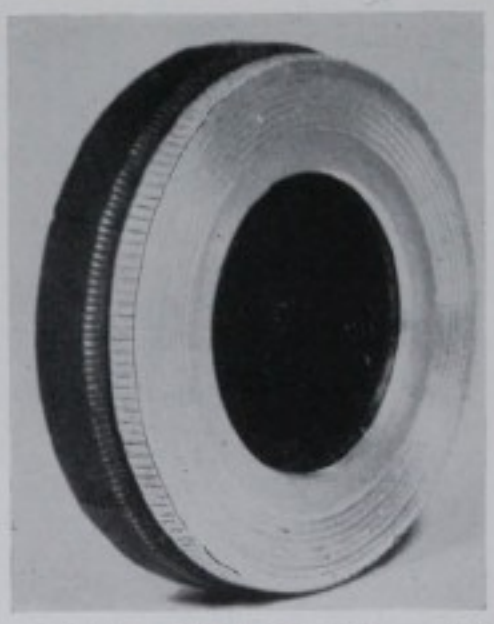

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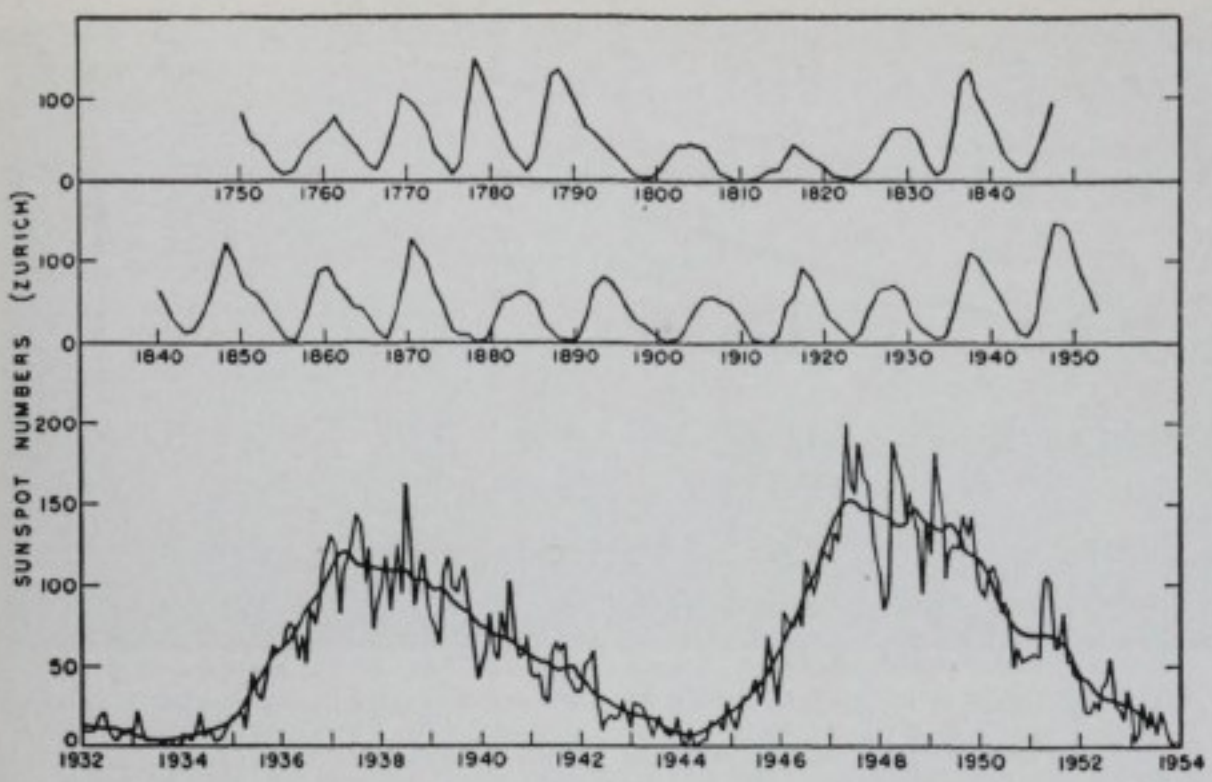

The sunspot numbers plotted here are computed by a formula in which the number of individual spots is added to 10 times the number of groups. For Zurich observations, a factor of 0.6 is applied. The upper curves give the yearly means of the smoothed monthly values; the lower curves are the observed monthly mean values (very irregular line) and the smoothed monthly values for the last two cycles. Reproduced from the "Publications" of the Astronomical Society of the Pacific.

Sunspot Activity in 1952 and 1953

ACCORDING to Dr. Seth B. Nicholson, of Mount Wilson and Palomar Observatories, the current minimum of sunspot activity may be reached in the middle of this year or a little later. In the April issue of the **Publications** of the Astronomical Society of the Pacific, he discusses the signs indicating that sunspot minimum is imminent, and presents the above graph.

On 350 days in 1953, solar observations were made at Mount Wilson, the previous record being 341 days in 1942. The 15 cloudy days were well distributed throughout the year. On 109 days, no spots were seen.

Dr. Nicholson points out that activity at the end of 1953 was at a minimum level, even below that of some earlier minima. The 1953 spots had a very low average latitude on the sun, and the new cycle will be marked by a rapid increase of high-latitude spots. The time of minimum is primarily established by the onrush of these new spots, which may occur at any time, and new-cycle spots should predominate in 1954.

Victor W. Killick, of Sacramento, Calif., points out that some interesting comparisons between sunspot activity in 1952 and 1953 can be made from the daily solar observations at the U. S. Naval Observatory, as reported in its **Circulars.** The average number of sunspots per day has declined from 16 in 1952 to five in 1953, while groups fell from 2.6 to 1.2. The average relative sunspot number was 42 in 1952, and 17 in 1953.

The total area of spots visible at any time is another useful index of solar activity. Expressed in millionths of the visible hemisphere of the sun, this area includes the umbra and penumbra of each spot. It is measured from photographs, allowance being made for foreshortening. The daily average sunspot area was 464 millionths in 1952, and diminished to 178 millionths in 1953.

Long-lived spots were rarer in 1953, when only six groups remained for more than one solar rotation, none of these making a third appearance. In 1952, 12 groups reappeared once, and two of these twice.

SUNSPOT NUMBERS

April 1-6, 0, 0; **7,** 2, 8; **8,** 5, 8; **9,** 2, 15; **10-13,** 0, 0; **14,** 1, 0; **15,** 3, 7; **16,** 3, 7; **17,** 1, 0; **18,** 2, 0; **19,** 0, 0; **20,** 0, 8; **21-30,** 0, 0. Means for April: 0.6 American; 1.8 Zurich.

Daily values of the observed mean relative sunspot numbers are given above. American numbers are computed by D. W. Rosebrugh from AAVSO Solar Division observations; Zurich numbers are from Zurich Observatory and its stations in Locarno and Arosa.

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GAMMA PERSEI AS A VISUAL DOUBLE STAR

Visual observers with telescopes of large aperture will have a favorable opportunity this year for verifying directly the binary nature of the bright star Gamma Persei. As reported in **Sky and Telescope** for March, 1948, page 124, Dr. Dean B. McLaughlin, of the University of Michigan Observatory, determined the spectroscopic orbit of this star.

The period is 14.7 years, and the apparent path of the companion is an elongated edgewise ellipse, so the stars move from positions very close to each other to separations as great as 0.4 second of arc, which is predicted for this summer. Since the spectra of both components are observable, their difference in brightness must be small.

Hence, during coming months, Gamma Persei should be readily recognizable as a close double star with telescopes of 15 inches aperture or more, under favorable seeing conditions. Expert double star observers should be able to detect the duplicity of the star with considerably smaller instruments.

As far as is known at this writing (May 15, 1954), Gamma Persei has yet to be observed visually as a double. **Sky and Telescope** will be glad to receive reports from successful observers in which the separation and position angle of the pair are given. (The long-known 10th-magnitude star one minute of arc away has nothing to do with this problem.)

METEORS IN JULY

Meteor observers this year will have favorable lunar conditions for the Delta Aquarid shower, that is, last quarter occurs on July 22nd, a day after the shower begins, and the moon is close to new at the time of maximum on the 28th. Delta Aquarids are usually slow except at a considerable distance from the radiant. Rates up to 30 per hour may be expected after midnight under good conditions. Many of the meteors have trains and a number of them are fairly bright.

In late July, observers may notice some Perseids late at night as very swift streaks, and may see other meteors from minor showers.

E. O.

PREDICTIONS OF BRIGHT MINOR PLANET POSITIONS

Psyche, 16, 9.2. July 7, 21:01.3 −14-44; 17, 20:55.3 −15-16; 27, 20:47.8 −15-54. Aug. 6, 20:39.6 −16-37; 16, 20:31.6 −17-19; 26, 20:25.0 −17-56.

Iris, 7, 7.9. July 17, 21:43.3 −5-55; 27, 21:36.8 −5-48. Aug. 6, 21:28.1 −5-57; 16, 21:18.3 −6-20; 26, 21:08.5 −6-53. Sept. 5, 21:00.2 −7-32.

Thetis, 17, 9.8. Aug. 16, 23:27.6 −9-07; 26, 23:20.8 −10-25. Sept. 5, 23:12.5 −11-43; 15, 23:03.9 −12-55; 25, 22:56.1 −13-50. Oct. 5, 22:50.3 −14-27.

After the asteroid's name are its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1954.0) for 0h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

OBSERVING THE MOON

Dr. Dinsmore Alter, director of the Griffith Observatory, is writing a book to be called **Introduction to the Moon.** Some excerpts, of considerable interest to lunar observers, have already appeared in the February, March, and May issues of the **Griffith Observer.** The first of these contains Lick photographs of the moon with a key to the identification of 146 lunar features.

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NORTON'S "Star Atlas and Reference Handbook," $5.25; Elger's moon map, $1.75; Moore, "Guide to the Moon," $3.95; "Radio Astronomy," $4.00; Lyttleton, "Comets," $5.00. All domestic and foreign books. Write for list. Herbert A. Luft, 42-10 82nd St., Elmhurst 73, N.Y.

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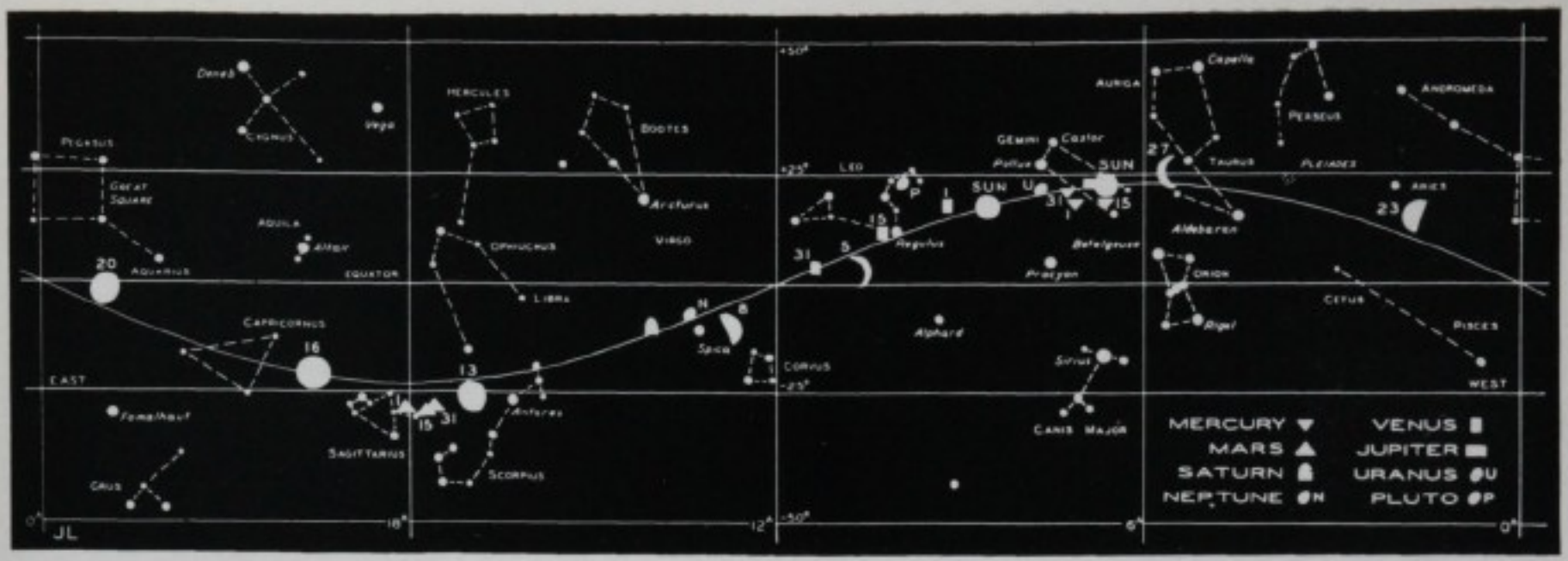

OCCULTATION PREDICTIONS

Data for the emersion of Kappa Piscium at stations **E** and **F** on July 19-20 was published in the June issue.

VARIABLE STAR MAXIMA

July 1, Z Puppis, 072820b, 7.9; 1, R Virginis, 123307, 6.9; 4, T Columbae, 051533, 7.6; 4, S Virginis, 132706, 7.1; 5, T Hydrae, 085008, 7.7; 6, Z Ursae Majoris, 115158, 6.6; 7, S Herculis, 164715, 7.6; 12, S Carinae, 100661, 5.7; 14, R Lyncis, 065355, 7.9; 16, V Canum Venaticorum, 131546, 7.1; 23, T Normae, 153654, 7.4; 24, S Ursae Majoris, 123961, 7.9; 27, R Horologii, 025050, 6.0; 29, R Draconis, 163266, 7.6. August 1, R Aurigae, 050953, 7.8; 4, V Ophiuchi, 162112, 7.5.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

MOON PHASES AND DISTANCE

First quarter	July 8,	1:33
Full moon	July 16,	0:29
Last quarter	July 23,	0:14
New moon	July 29,	22:20
First quarter	August 6,	18:50

	July		Distance	Diameter
Apogee	9,	8h	251,200 mi.	29′ 33″
Perigee	23,	19h	229,600 mi.	32′ 20″
	August			
Apogee	6,	3h	251,200 mi.	29′ 33″

MINIMA OF ALGOL

July 2, 19:44; 5, 16:32; 8, 13:21; 11, 10:10; 14, 6:59; 17, 3:48; 20, 0:36; 22, 21:24; 25, 18:13; 28, 15:01; 31, 11:50. August 3, 8:39; 6, 5:27.

These minima predictions for Algol are based on the formula in the 1953 **International Supplement** of the Cracow Observatory. The times given are geocentric; they can be compared directly with observations.

UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.

THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Mercury passes inferior conjunction with the sun on July 6th, entering the morning sky. Greatest elongation is attained on July 27th, 19° 49′ west of the sun. Then Mercury will be magnitude +0.5, rising 1½ hours before the sun. On the 28th Mercury will pass 1° 55′ south of Jupiter, with the crescent moon nearby.

Venus is not favorably situated for observers in northern latitudes, setting two hours after the sun. During July, Venus moves eastward across the entire constellation of Leo, passing 1° north of Regulus on the 12th. On the 15th, this brilliant planet appears in a telescope as a disk 15″ in diameter, 72 per cent illuminated.

Mars will be nearest the earth this year on July 2nd, 39,770,000 miles distant. The red planet will then be visible nearly all night as a brilliant −2.2-magnitude object. Mars is in retrograde motion in western Sagittarius till July 29th, when it resumes eastward motion. Due to its declination of 28° south, Mars is low for observers in northerly latitudes, and it will set four hours after it crosses the meridian. The Martian disk will be nearly 22″ in diameter in early July, only 3″ less than at the most favorable opposition.

Jupiter reappears in the morning sky late in July, after having been hidden in the solar glare for about a month. On the morning of the 28th, Jupiter will be very close to the crescent moon as they rise together 1½ hours before the sun. One may see the ending of an occultation of Jupiter, which, however, is not predicted in the **Ephemeris,** as it is too close to the sun.

Saturn, at eastern quadrature with the sun on July 26th, is visible only during evening hours. The planet is in eastern Virgo, and of magnitude +0.8.

Uranus is in conjunction with the sun on the 16th, and hence is not visible.

Neptune must be looked for during evening hours, as eastern quadrature occurs on July 16th. This distant planet is moving slowly eastward, about 30′ west of 77 Virginis.

E. O.

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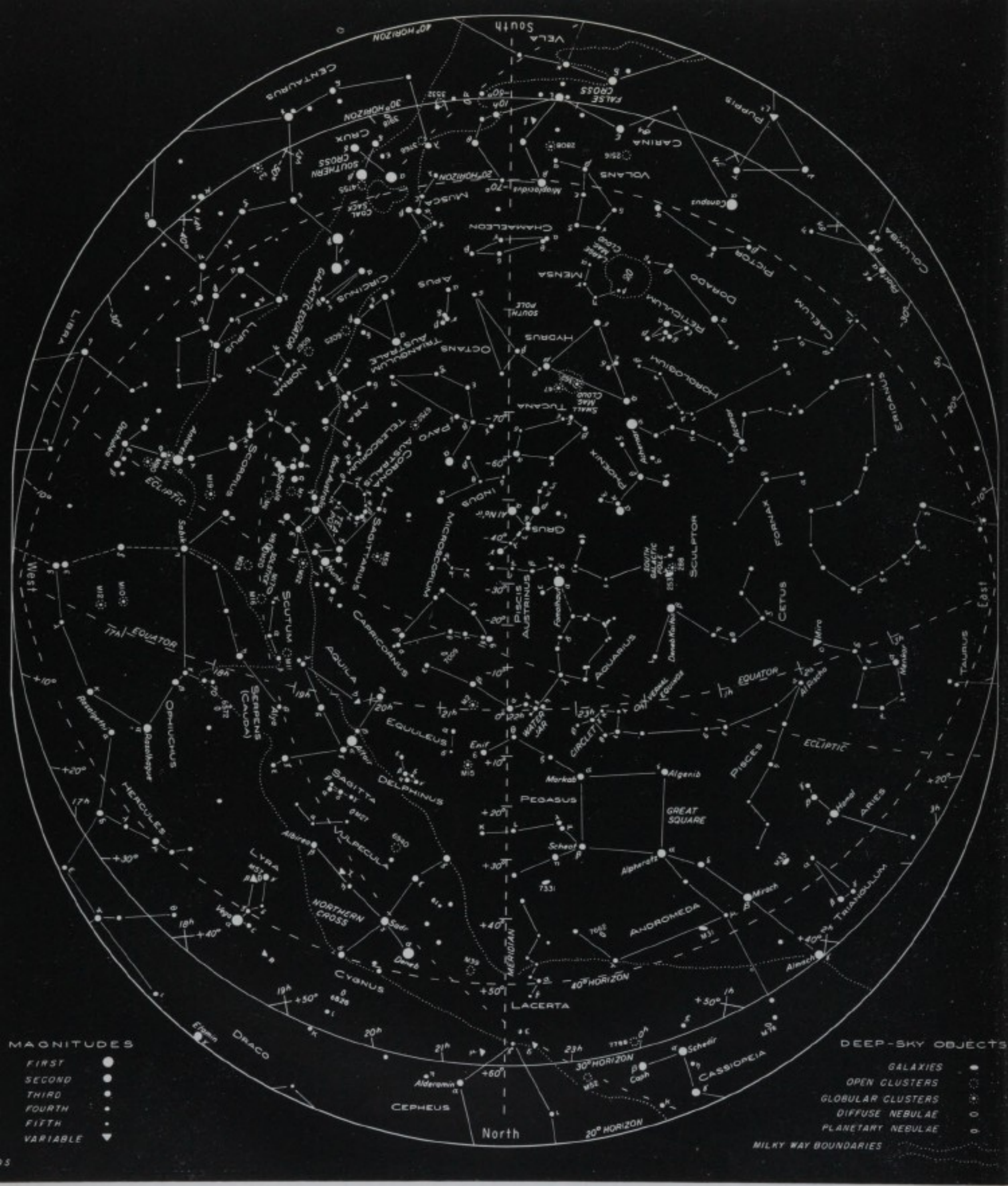
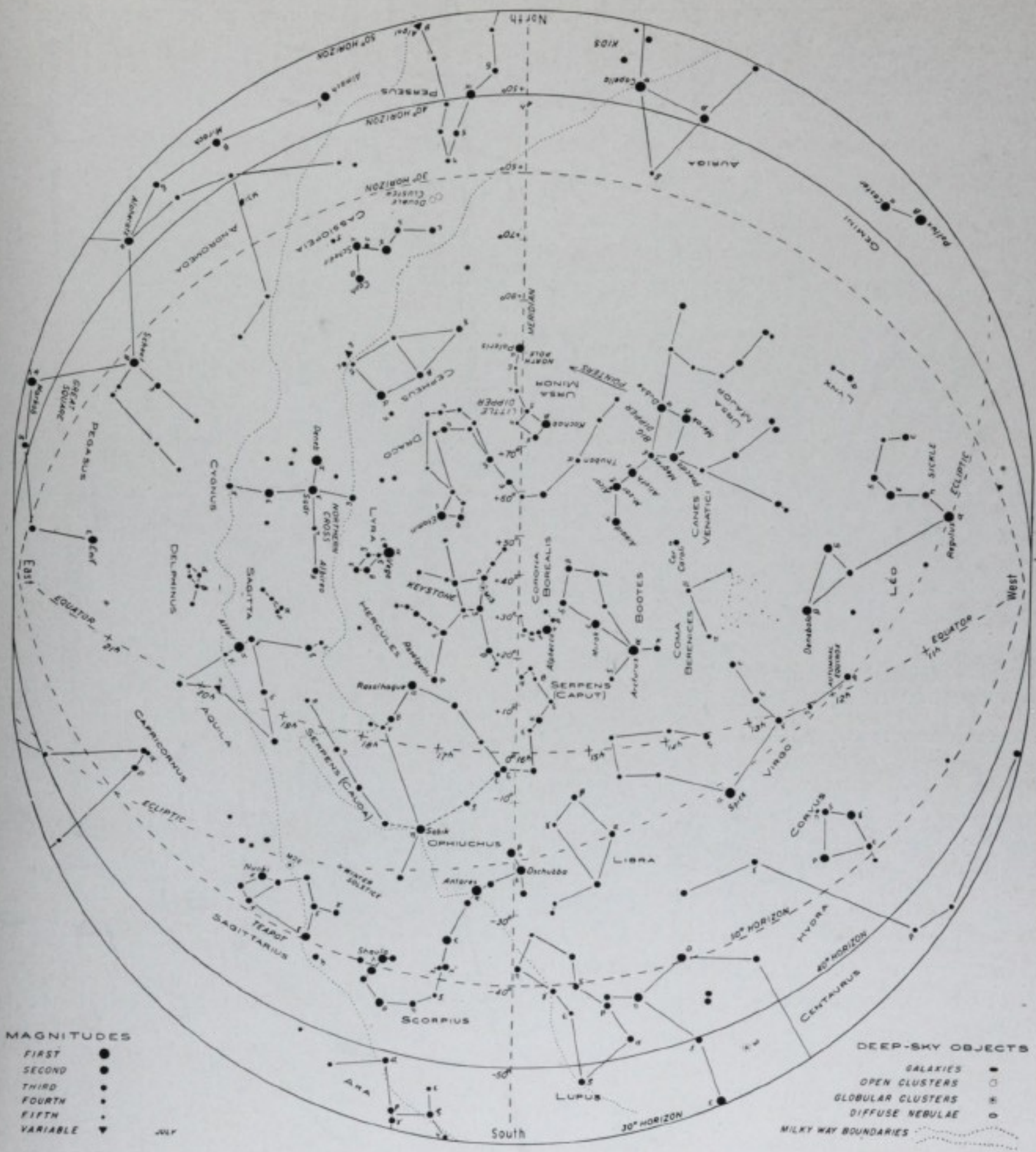


SOUTHERN STARS

The sky as seen from latitudes 20° to 40° south, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of October, respectively; also, at 7 p.m. and 6 p.m. on November 7th and 23rd. For other times, add or subtract ½ hour per week. When facing south, hold "South" at the bottom; turn the chart correspondingly for other directions. Celestial hour circles and parallels are represented as parts of circles, and an observer's horizon is always a circle on the stereographic projection used in this chart.



The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of July, respectively.

STARS FOR JULY

DURING midsummer evenings, one of the most interesting constellations is Scorpius, low in the southern sky. To dwellers in the northern United States, stars as far south as those in the Scorpion's tail are not usually conspicuous, and the upper, most easily seen part of the Scorpion appears shaped like the Greek letter lambda (λ) in the lower left part of which is 1st-magnitude Antares.

But with a clear southern horizon, and in more southerly states, the whole of the constellation is striking, for it abounds in 2nd- and 3rd-magnitude stars.

The red color of Antares is noticeable, particularly when it is compared with the bluish-white of Spica in the southwestern sky. The name Antares means "rival to Mars," and its appropriateness is easy to check this year, for Mars is in the neighboring constellation, Sagittarius, which is rising in the southeast these evenings.

A keen eye with a little practice can soon learn to distinguish differences in the colors or hues of stars that are overlooked at first. The brighter a star appears, the easier its color is to recognize; therefore, binoculars or field glasses are helpful. Near the horizon, however, all stars are reddened, and their relative colors should be judged when they are at least 20° or 30° high. It is a striking experiment to watch in a telescope how Sirius or Venus sets on a sea horizon: the color changes from white through yellow and orange, becoming blood red in the last seconds before disappearing.

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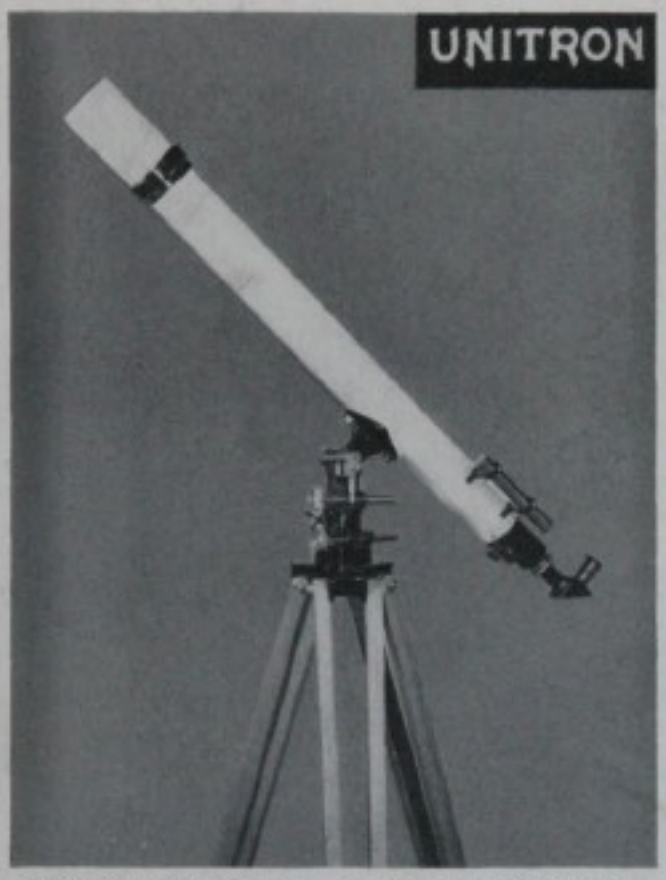

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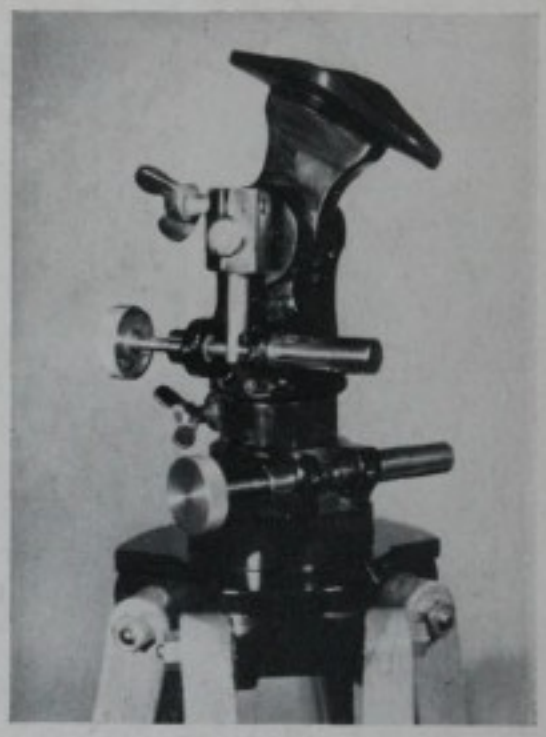

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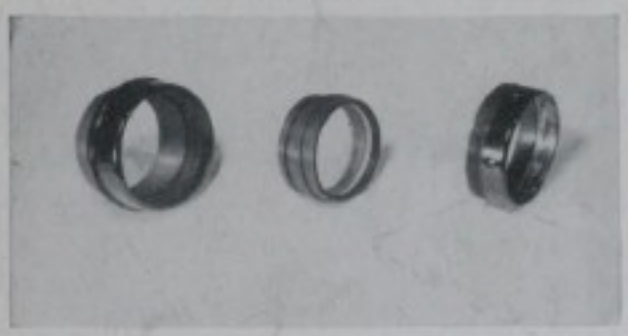

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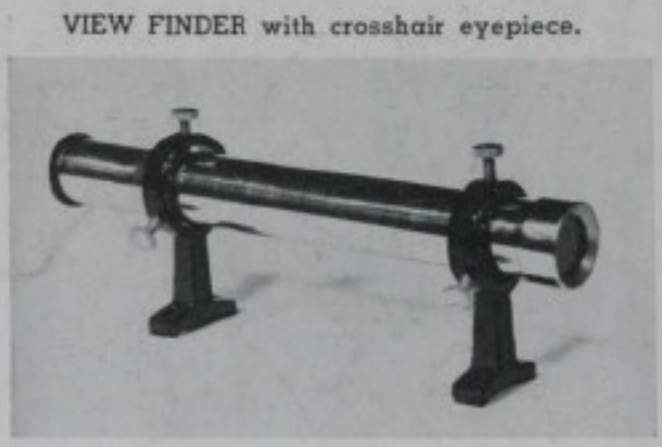

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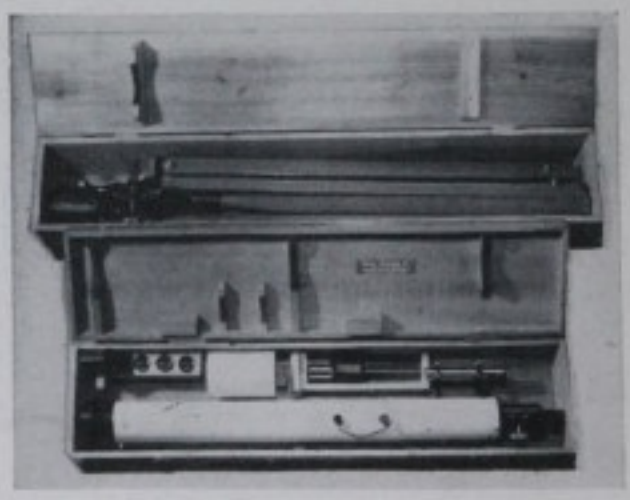

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